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Editorial

Dear Colleagues,

It is our pleasure to present you the 220$^{\rm th}$ issue of the AGB Newsletter. Please check out the many interesting results, and several announcements of scientific meetings and a Ph.D. position.

Those of you who are a member of IAU Commission G3 "Stellar Evolution" will have noticed that we are defining the most useful way forward to support and promote research into the evolution of stars, and AGB stars of course feature prominently in that. Also, the Working Group "Abundances in Red Giants" will undergo a make-over – stay tuned! If you are not yet a member of the IAU or Commission G3 then we hope you soon will be.

Last month's *Food for Thought* ("We owe our lives to AGB stars") generated some interesting responses. Noam Soker sugggests that "massive stars with core collapse SNe can form enough elements to have life", i.e. AGB stars may not be needed, but that, "definitely we owe our death to RGB and AGB stars, as when the Sun becomes a RGB star we will all be dead (at least on Earth), and during the AGB, we might lose our real-estate as Earth will be evaporated in the Sun envelope." Of course, dust grains are required for life to form as well – do we need AGB stars for that? And what about radio-active material such as ^{26}Al, to keep Earth's core molten? Ramiro de la Reza offers a different view: "this is the case [that we owe our lives to AGB stars] if the complex organic compounds formed in the winds of the short lifetime (few thousand years) pre-planetary nebula stage is the first source of material for the life in our Solar System. But we have recently found (de la Reza et al. 2015, ApJ, 806, 86) that these very last stages of AGB stars are not the only source of organics. We have found that K-type RGB stars at the luminosity bump have produced the same organic compounds. This happens only when these giant 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. It must be pointed out that not only these RGB [stars] became a second source or factory of these organics, but that the way in which these shells appear give support to [Sun] Kwok's suggestion that these organic compounds are solid nano particles. It is in fact very impressive to find today that the surface of the Churyumov–Gerasimenko comet or the large dunes of Titan are covered and formed by solid organic compounds."

Marian Martínez González responded to the previous *Food for Thought*: "the main difference [between turbulence and convection] is that turbulence is a multi-scale phenomenon, while convection is defined by a characteristic scale. In the Sun, convective cells form the granular pattern ($\sim$ 1 Mm), as well as the supergranular one ($\sim$ 30 Mm). The magnetic field at the surface is turbulent forming loops at all scales, from the largest active regions down to few km, where it is dissipated." Many thanks for all of your thoughts!

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

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

Food for Thought

This month's thought-provoking statement is:

What is the fraction of CH and CEMP stars that have a white dwarf companion?

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)

Do you have a cool picture or graph to show? Want it displayed on the cover of the AGB Newsletter? Sned your contribution to astro.agbnews@keele.ac.uk

Refereed Journal Papers

Chemical analysis of asymptotic giant branch stars in M 62

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We have collected UVES-FLAMES high-resolution spectra for a sample of 6 asymptotic giant branch (AGB) and 13 red giant branch (RGB) stars in the Galactic globular cluster M 62 (NGC 6266). Here we present the detailed abundance analysis of iron, titanium, and light-elements (O, Na, Al and Mg). For the majority (5 out 6) of the AGB targets we find that the abundances, of both iron and titanium, determined from neutral lines are significantly underestimated with respect to those obtained from ionized features, the latter being, instead, in agreement with those measured for the RGB targets. This is similar to recent findings in other clusters and may suggest the presence of Non-Local Thermodynamical Equilibrium (NLTE) effects. In the O–Na, Al–Mg and Na–Al planes, the RGB stars show the typical correlations observed for globular cluster stars. Instead, all the AGB targets are clumped in the regions where first generation stars are expected to lie, similarly to what recently found for the AGB population of NGC 6752. While the sodium and aluminum abundance could be underestimated as a consequence of the NLTE bias affecting iron and titanium, the used oxygen line does not suffer from the same effects and the lack of O-poor AGB stars therefore is solid. We can thus conclude that none of the investigated AGB stars belong to the second stellar generation of M 62. We also find a RGB star with extremely high sodium abundance ([Na/Fe] = +1.08 dex).

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Laboratory oscillator strengths of Sc I in the near infrared region for astrophysical applications

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Context: Atomic data is crucial for astrophysical investigations. In order to understand the formation and evolution of stars, we need to analyse their observed spectra. Analysing a spectrum of a star requires information about the properties of atomic lines, e.g., wavelengths and oscillator strengths. However, atomic data of some elements are scarce, particularly in the infrared region and this paper is part of an effort improving the situation on near-IR atomic data.

Aims: This paper investigates the spectrum of neutral scandium, Sc I, from laboratory measurements and improves the atomic data of Sc I lines in the infrared region covering lines in R, I, J and K band. Especially, we focus on measuring oscillator strengths for Sc I lines connecting the levels with 4p and 4s configurations.

Methods: We combined experimental branching fractions with radiative lifetimes from the literature to derive oscillator strengths (f-values). Intensity calibrated spectra with high spectral resolution were recorded with Fourier transform spectrometer from a hollow cathode discharge lamp. The spectra were used to derive accurate oscillator strengths and wavelengths for Sc I lines, with emphasis on the infrared region.

Results: This project provides the first set of experimental Sc I lines in the near-infrared region for accurate spectral analysis of astronomical objects. We derived 63 $\log gf$ values for the lines between 5300 Å and 24300 Å. The uncertainties in the f-values vary from 5% to 20%. The small uncertainties in our values allow for an increased accuracy in astrophysical abundance determinations.

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and from http://dx.doi.org/10.1051/0004-6361/201526813

The complex environment of the bright carbon star TX Psc as probed by spectro-astrometry

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Context: Stars on the asymptotic giant branch (AGB) show broad evidence of inhomogeneous atmospheres and circumstellar envelopes. These have been studied by a variety of methods on various angular scales. In this paper we explore the envelope of the well-studied carbon star TX Psc by the technique of spectro-astrometry.
Aims: We explore the potential of this method for detecting asymmetries around AGB stars.
Methods: We obtained CRIRES observations of several CO $\Delta v = 1$ lines near 4.6 μm and HCN lines near 3 μm in 2010 and 2013. These were then searched for spectro-astrometric signatures. For the interpretation of the results, we used simple simulated observations.
Results: Several lines show significant photocentre shifts with a clear dependence on position angle. In all cases, tilde-shaped signatures are found where the positive and negative shifts (at PA 0°) are associated with blue and weaker red components of the lines. The shifts can be modelled with a bright blob 70 mas to 210 mas south of the star with a flux of several percent of the photospheric flux. We estimate a lower limit of the blob temperature of 1000 K. The blob may be related to a mass ejection as found for AGB stars or red supergiants. We also consider the scenario of a companion object.
Conclusions: Although there is clear spectro-astrometric evidence of a rather prominent structure near TX Psc, it does not seem to relate to the other evidence of asymmetries, so no definite explanation can be given. Our data thus underline the very complex structure of the environment of this star, but further observations that sample the angular scales out to a few hundred milli-arcseconds are needed to get a clearer picture.

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Chemical evolution of the inner 2 degrees of the Milky Way Bulge: [α/Fe] trends and metallicity gradients

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The structure, formation, and evolution of the Milky Way bulge is a matter of debate. Important diagnostics for discriminating between models of bulge formation and evolution include α-abundance trends with metallicity, and spatial abundance and metallicity gradients. Due to the severe optical extinction in the inner Bulge region, only a few detailed investigations have been performed of this region. Here we aim at investigating the inner 2 degrees of the Bulge (projected galactocentric distance of approximately 300 pc), rarely investigated before, by observing the [α/Fe] element trends versus metallicity, and by trying to derive the metallicity gradient in the $b < 2°$ region. [α/Fe] and metallicities have been determined by spectral synthesis of 2-μm spectra of 28 M-giants in the Bulge, lying along the Southern minor axis at $(l, b) = (0, 0)$, $(0, -1°)$, and $(0, -2°)$. These were observed with the CRIRES spectrometer at the Very Large Telescope, VLT at high spectral resolution. Low-resolution K-band spectra, observed with the ISAAC spectrometer at the VLT, are used to determine the effective temperature of the stars. We present the first connection between the Galactic Center and the Bulge using similar stars, high spectral resolution, and analysis techniques. The [α/Fe] trends in all our three fields show a large similarity among each other and with trends further out in the Bulge. All point to a rapid star-formation episode in the Bulge. We find that there is a lack of an [α/Fe] gradient in the Bulge all the way into the centre, suggesting a homogeneous Bulge when it comes to the enrichment process and

star-formation history. We find a large range of metallicities from $-1.2 <$ [Fe/H] $< +0.3$, with a lower dispersion in the Galactic center: $-0.2 <$ [Fe/H] $< +0.3$. The derived metallicities of the stars in the three fields get, in the mean, progressively higher the closer to the Galactic plane they lie. We could interpret this as a continuation of the metallicity gradient established further out in the Bulge, but due to the low number of stars and possible selection effects, more data of the same sort as presented here is necessary to conclude on the inner metallicity gradient from our data alone. Our results firmly argues for the center being in the context of the Bulge rather than very distinct.

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Searching for OH maser emission towards the MIPSGAL compact Galactic bubbles

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We conducted radio observations searching for OH 18-cm maser emission from a sample of 169 unclassified MIPSGAL compact Galactic bubbles. These sources are thought to be the circumstellar envelopes of different kinds of evolved stars. Our observations were aimed at shedding light on the nature of MIPSGAL bubbles, since their characterization is a fundamental aid for the development of accurate physical models of stellar and Galaxy evolution. The maser emission is observationally linked to the last stages of the life of low- and intermediate-mass stars, which may constitute a significant fraction of the MIPSGAL bubbles. In particular OH masers are usually observed towards post-asymptotic giant branch (post-AGB) stars. Our observations were performed with the Green Bank Telescope and, for each source, produced spectra around the four OH 18-cm transitions. The observations were compared with archive interferometer data in order to exclude possible contamination from nearby sources. The main result is that the OH maser emission is not a common feature among the MIPSGAL bubbles, with only one certain detection. We conclude that among the MIPSGAL bubbles the post-AGB stars could be very rare.

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Co-spatial long-slit UV/optical spectra of ten Galactic planetary nebulæ with HST/STIS. II. Nebular models, central star properties and He+CNO synthesis

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The goal of the present study is twofold. First, we employ new HST/STIS spectra and photoionization modeling techniques to determine the progenitor masses of eight planetary nebulæ (IC 2165, IC 3568, NGC 2440, NGC 3242, NGC 5315, NGC 5882, NGC 7662 and PB 6). Second, for the first time we are able to compare each object's observed nebular abundances of helium, carbon and nitrogen with abundance predictions of these same elements by a stellar

model that is consistent with each object's progenitor mass. Important results include the following: 1) the mass range of our objects' central stars matches well with the mass distribution of other PN central stars and white dwarfs; 2) He/H is above solar in all of our objects, in most cases likely due to the predicted effects of first dredge up; 3) most of our objects show negligible C enrichment, probably because their low masses preclude 3rd dredge-up; 4) C/O versus O/H for our objects appears to be inversely correlated, perhaps consistent with the conclusion of theorists that the extent of atmospheric carbon enrichment from first dredge-up is sensitive to a parameter whose value increases as metallicity declines; 5) stellar model predictions of nebular C and N enrichment are consistent with observed abundances for progenitor star masses $\leq$ 1.5 $M_{\odot}$. Finally, we present the first published photoionization models of NGC 5315 and NGC 5882.

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Identification of dusty massive stars in star-forming dwarf irregular galaxies in the Local Group with mid-IR photometry

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Increasing the statistics of spectroscopically confirmed evolved massive stars in the Local Group enables the investigation of the mass loss phenomena that occur in these stars in the late stages of their evolution. We aim to complete the census of luminous mid-IR sources in star-forming dwarf irregular (dIrr) galaxies of the Local Group. To achieve this we employed mid-IR photometric selection criteria to identify evolved massive stars, such as red supergiants (RSGs) and luminous blue variables (LBVs), by using the fact that these types of stars have infrared excess due to dust. The method is based on 3.6 μm and 4.5 μm photometry from archival *Spitzer* Space Telescope images of nearby galaxies. We applied our criteria to 4 dIrr galaxies: Pegasus, Phoenix, Sextans A, and WLM, selecting 79 point sources, which we observed with the VLT/FORS2 spectrograph in multi-object spectroscopy mode. We identified 13 RSGs, of which 6 are new discoveries, also 2 new emission line stars, and 1 candidate yellow supergiant. Among the other observed objects we identified carbon stars, foreground giants, and background objects, such as a quasar and an early-type galaxy that contaminate our survey. We use the results of our spectroscopic survey to revise the mid-IR and optical selection criteria for identifying RSGs from photometric measurements. The optical selection criteria are more efficient in separating extragalactic RSGs from foreground giants than mid-IR selection criteria, however the mid-IR selection criteria are useful for identifying dusty stars in the Local Group. This work serves as a basis for further investigation of the newly discovered dusty massive stars and their host galaxies.

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AGB stars in the SMC: evolution and dust properties based on *Spitzer* observations

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We study the population of asymptotic giant branch (AGB) stars in the Small Magellanic Cloud (SMC) by means of full evolutionary models of stars of mass 1 $M_{\odot} \leq M \leq 8$ $M_{\odot}$, evolved through the thermally pulsing phase. The models also account for dust production in the circumstellar envelope. We compare *Spitzer* infrared colours with results from theoretical modelling.

We show that $\sim 75\%$ of the AGB population of the SMC is composed by scarcely obscured objects, mainly stars of mass $M \leq 2$ $M_\odot$ at various metallicity, formed between 700 Myr and 5 Gyr ago; $\sim 70\%$ of these sources are oxygen-rich stars, while $\sim 30\%$ are carbon stars.
The sample of the most obscured AGB stars, accounting for $\sim 25\%$ of the total sample, is composed almost entirely by carbon stars. The distribution in the colour–colour ([3.6]–[4.5], [5.8]–[8.0]) and colour–magnitude ([3.6]–[8.0], [8.0]) diagrams of these C-rich objects, with a large infrared emission, traces an obscuration sequence, according to the amount of carbonaceous dust in their surroundings. The overall population of C-rich AGB stars descends from 1.5–2 $M_\odot$ stars of metallicity $Z = 4 \times 10^{-3}$, formed between 700 Myr and 2 Gyr ago, and from lower metallicity objects, of mass below 1.5 $M_\odot$, 2–5 Gyr old.
We also identify obscured oxygen-rich stars ($M \sim 4$–6 $M_\odot$) experiencing hot bottom burning. The differences between the AGB populations of the SMC and LMC are also commented.

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GalevNB: a conversion from N-body simulations to observations

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We present GalevNB (Galev for N-body simulations), a utility that converts fundamental stellar properties of N-body simulations into observational properties using the Galev (Galaxy evolutionary synthesis models) package, and thus allowing direct comparisons between observations and N-body simulations. It works by converting fundamental stellar properties, such as stellar mass, temperature, luminosity and metallicity into observational magnitudes for a variety of filters of mainstream instruments/telescopes, such as HST, ESO, SDSS, 2MASS, etc.), and into spectra that spans from far-UV (90 Å) to near-IR (160 μm). As an application, we use GalevNB to investigate the secular evolution of spectral energy distribution (SED) and color–magnitude diagram (CMD) of a simulated star cluster over a few hundred million years. With the results given by GalevNB we discover an UV-excess in the SED of the cluster over the whole simulation time. We also identify four candidates that contribute to the FUV peak, core helium burning stars, thermal pulsing asymptotic giant branch (TPAGB) stars, white dwarfs and naked helium stars.

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Dust formation in the oxygen-rich AGB star IK Tau

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Aims: We model the synthesis of molecules and dust in the inner wind of the oxygen-rich Mira-type star IK Tau by considering the effects of periodic shocks induced by the stellar pulsation on the gas and by following the non-equilibrium chemistry in the shocked gas layers between 1 $R_\star$ and 10 $R_\star$. We consider a very complete set of molecules

and dust clusters, and combine the nucleation phase of dust formation with the condensation of these clusters into dust grains. We also test the impact of increasing the local gas density. Our derived molecular abundances and dust properties are compared to the most recent observational data.
Methods: A semi-analytical formalism based on parameterised fluid equations is used to describe the gas density, velocity, and temperature in the inner wind. The chemistry is described by using a chemical kinetic network of reactions and the condensation mechanism is described by a Brownian formalism. A set of stiff, ordinary, coupled differential equations is solved, and molecular abundances, dust cluster abundances, grain size distributions and dust masses are derived.
Results: The shocks drive an active non-equilibrium chemistry in the dust formation zone of IK Tau where the collision destruction of CO in the post-shock gas triggers the formation of C-bearing species such as HCN and CS. Most of the modelled molecular abundances agree well with the latest values derived from *Herschel* data, except for SO_2 and NH_3, whose formation may not occur in the inner wind. Clusters of alumina, Al_2O_3, are produced within 2 $R_\star$ and lead to a population of alumina grains close to the stellar surface. Clusters of silicates (Mg_2SiO_4) form at larger radii ($r > 3$ $R_\star$), where their nucleation is triggered by the formation of HSiO and H_2SiO. They efficiently condense and reach their final grain size distribution between ~ 6 $R_\star$ and 8 $R_\star$ with a major population of medium size grains peaking at ~ 200 Å. This two dust-shell configuration agrees with recent interferometric observations. The derived dust-to-gas mass ratio for IK Tau is in the range $1–6 \times 10^{-3}$ and agrees with values derived from observations of O-rich Mira-type stars.
Conclusions: Our results confirm the importance of periodic shocks in chemically shaping the inner wind of AGB stars and providing gas conditions conducive to the efficient synthesis of molecules and dust by non-equilibrium processes. They indicate that the wind acceleration will possibly develop in the radius range 4–8 $R_\star$ in IK Tau.

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The PNe and H II regions in NGC 6822 revisited. Hints on AGB nucleosynthesis

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The chemical behaviour of an ample sample of PNe in NGC 6822 is analyzed. Spectrophotometric data of 11 PNe and two H II regions were obtained with the OSIRIS spectrograph attached to the Gran Telescopio Canarias. Data for other 13 PNe and three H II regions were retrieved from the literature. Physical conditions and chemical abundances of O, N, Ne, Ar and S were derived in a consistent way, for 19 PNe and 4 H II regions. Abundances in the PNe sample are widely distributed showing $12 + \log(O/H)$ from 7.4 to 8.2 and $12 + \log(Ar/H)$ from 4.97 to 5.80. Two groups of PNe can be differentiated: one old, with low metallicity ($12 + \log(O/H) < 8.0$ and $12 + \log(Ar/H) < 5.7$) and another younger with metallicities similar to the values of H II regions. The old objects are distributed in a larger volume than the young ones. An important fraction of PNe (over 30%) was found to be highly N-rich (Peimbert Type I PNe). Such PNe occur at any metallicity. In addition, about 60% of the sample presents high ionization ($He^{2+}/He \geq 0.1$), possessing a central star with effective temperature larger than 100,000 K. Possible bias in the sample are discussed. From comparison with stellar evolution models by Karakas (2010) and Fishlock et al. (2014) of the observed N/O abundance ratios, our PNe should have had initial masses lower than 4 $M_\odot$, although if the comparison is made with Ne vs. O abundances, the initial masses should have been lower than 2 $M_\odot$. It appears that these models of stars of 2–3 $M_\odot$ are producing too much ^{22}Ne in the stellar surface at the end of the AGB. On the other hand, the comparison with another set of stellar evolution models by Ventura et al. (2013, 2014a, 2014b), with a different treatment of convection and on the assumptions concerning the overshoot of the convective core during the core H-burning phase, provided a reasonable agreement between N/O and Ne/H observed and predicted ratios if initial masses of more massive stars are of about 4 $M_\odot$.

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To Ba or not to Ba: Enrichment in s-process elements in binary systems with WD companions of various masses

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The enrichment in s-process elements of barium stars is known to be due to pollution by mass transfer from a companion formerly on the thermally-pulsing asymptotic giant branch (AGB), now a carbon–oxygen white dwarf (WD). This paper investigates the relationship between the s-process enrichment in the barium star and the mass of its WD companion. It is expected that helium WDs, which have masses smaller than about 0.5 $M_\odot$ and never reached the AGB phase, should not pollute with s-process elements their giant companion, which should thus never turn into a barium star. Spectra with a resolution of $R \sim 86\,000$ were obtained with the HERMES spectrograph on the 1.2-m *Mercator* telescope for a sample of 11 binary systems involving WD companions of various masses. We use standard 1D LTE MARCS model atmospheres coupled with the TURBOSPECTRUM radiative-transfer code to derive the atmospheric parameters using equivalent widths of Fe I and Fe II lines. The abundances of s-process elements for the entire sample of 11 binary stars were derived homogeneously. The sample encompasses all levels of overabundances: from solar [s/Fe] = 0 to 1.5 dex in the 2 binary systems with S-star primaries (for which dedicated MARCS model atmospheres were used). The primary components of binary systems with a WD more massive than 0.5 $M_\odot$ are enriched in s-process elements. We also found a trend of increasing [s/Fe] with [C/Fe] or [(C+N)/Fe]. Our results conform to the expectation that binary systems with WD companions less massive than 0.5 $M_\odot$ do not host barium stars.

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Binary properties of CH and carbon-enhanced metal-poor stars

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The HERMES spectrograph installed on the 1.2-m *Mercator* telescope has been used to monitor the radial velocity of 13 low-metallicity carbon stars, among which 7 Carbon-Enhanced Metal-Poor (CEMP) stars and 6 CH stars. All stars but one show clear evidence for binarity. New orbits are obtained for 8 systems. The sample covers an extended range in orbital periods, extending from 3.4 d (for the dwarf carbon star HE 0024−2523) to about 54 yr (for the CH star HD 26, the longest known among barium, CH and extrinsic S stars). Three systems exhibit low-amplitude velocity variations with periods close to 1 yr superimposed on a long-term trend. In the absence of an accurate photometric monitoring of these systems, it is not clear yet whether these variations are the signature of a very low-mass companion, or of regular envelope pulsations. The period–eccentricity (P–e) diagram for the 40 low-metallicity carbon stars with orbits now available shows no difference between CH and CEMP-s stars (the latter corresponding to those CEMP stars enriched in s-process elements, as are CH stars). We suggest that they must be considered as one and the same family and that their different names only stem from historical reasons. Indeed, these two families have as well very similar mass-function distributions, corresponding to companions with masses in the range 0.5–0.7 $M_\odot$, indicative of white-dwarf companions, adopting 0.8–0.9 $M_\odot$ for the primary component. This result confirms that CH and CEMP-s stars obey the same mass-transfer scenario as their higher-metallicity analogs, the barium stars. The P–e diagrams

of barium, CH and CEMP-s stars are indeed very similar. They reveal two different groups of systems: one with short orbital periods ($P < 1000$ d) and mostly circular or almost circular orbits, and another with longer-period and eccentric ($e > 0.1$) orbits.

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High-resolution CO observation of the carbon star CIT 6 revealing the spiral structure and a nascent bipolar outflow

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CIT 6 is a carbon star in the transitional phase from the asymptotic giant branch (AGB) to the proto-planetary nebulæ (pPN). Observational evidences of two point sources in the optical, circumstellar arc segments in an HC_3N line emission, and a bipolar nebula in near-infrared provide strong support for the presence of a binary companion. Hence, CIT 6 is very attractive for studying the role of companions in the AGB-pPN transition. We have carried out high resolution ^{12}CO $J = 2$–1 and ^{13}CO $J = 2$–1 observations of CIT 6 with the Submillimeter Array combined with the Submillimeter Telescope (single-dish) data. The ^{12}CO channel maps reveal a spiral-shell pattern connecting the HC_3N segments in a continuous form, and an asymmetric outflow corresponding to the near-infrared bipolar nebula. Rotation of the ^{12}CO channel peak position may be related to the inner spiral winding and/or the bipolar outflow. An eccentric orbit binary is suggested for the presences of an anisotropic mass loss to the west and a double spiral pattern. The lack of inter-arm emission to the west may indicate a feature corresponding to the periastron passage of a highly eccentric orbit of the binary. Spatially-averaged radial and spectral profiles of ^{12}CO $J = 2$–1 and ^{13}CO $J = 2$–1 are compared with simple spherical radiative transfer models, suggesting a change of ^{12}CO/^{13}CO abundance ratio from ~ 30 to ~ 50 inward in the circumstellar envelope of CIT 6. The millimeter continuum emission is decomposed into extended dust thermal emission (spectral index ~ -2.4) and compact emission from radio photosphere (spectral index ~ -2.0).

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The weather report from IRC +10°216: Evolving irregular clouds envelop carbon star

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High angular resolution images of IRC +10°216 are presented in several near infrared wavelengths spanning more than 8 years. These maps have been reconstructed from interferometric observations obtained at both Keck and the VLT, and also from stellar occultations by the rings of Saturn observed with the *Cassini* spacecraft. The dynamic inner

regions of the circumstellar environment are monitored over eight epochs ranging between January 2000 and July 2008. The system is shown to experience substantial evolution within this period including the fading of many previously reported persistent features, some of which had been identified as the stellar photosphere. These changes are discussed in context of existing models for the nature of the underlying star and the circumstellar environment. With access to these new images, we are able to report that none of the previously identified bright spots in fact contain the star, which is buried in its own dust and not directly visible in the near infrared.

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Evolution of the dust in V4332 Sagittarii

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An eruptive nova-like event took place in 1994 in the stellar-merger candidate V4332 Sgr. Following the eruption, dust consisting of refractory silicate rich dust grains containing a significant component of AlO bonding was formed sometime between 1998 and 2003. Observations using *Spitzer* between 2005 and 2009 show significant changes in the 10-μm silicate stretch feature. There is a deepening of the 10-μm silicate stretch as well as the development of a feature between about 13 and 20 μm consistent with a blend of the MgO and FeO stretching features and the O–Si–O bending mode of increasingly ordered silicate dust. Near-infrared observations show the presence of AlO and water vapor in the outflow in 2003, 2004 and 2005: the AlO has significantly decreased in spectra obtained in 2014 while the water vapor remains largely unchanged. An attempt is made to correlate these observations and understand the significance of these changes using DUSTY modeling. The observations appear consistent with the kinetically-controlled, condensation of highly under-oxidized SiO/AlO/Fe/Mg dust grains in the outflow followed by the continuous evolution of the initial condensate due to thermal annealing and oxidation of the dust via reaction with ambient O, OH and H_2O in the expanding, cooling shell. Periodic monitoring of this dust shell over the mid-infrared spectral range could yield useful information on the evolution of under-oxidized silicate condensates exposed to hot water vapor in more conventional circumstellar environments.

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HE 0017+0055 : A probable pulsating CEMP-rs star and long-period binary

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A radial-velocity monitoring of the Carbon-Enhanced Metal-Poor (CEMP) star HE 0017+0055 over 8 years with the Nordic Optical Telescope and *Mercator* telescopes reveals variability with a period of 384 d and amplitude of 540 ± 27 m s^{-1}, superimposed on a nearly linear long-term decline of ~ 1 m s^{-1} day^{-1}. High-resolution HERMES/*Mercator* and Keck/HIRES spectra have been used to derive elemental abundances using 1-D LTE MARCS models. A metallicity

of [Fe/H] ~ -2.4 is found, along with s-process overabundances on the order of 2 dex (with the exception of [Y/Fe] $\sim +0.5$), and most notably overabundances of r-process elements like Sm, Eu, Dy, and Er in the range 0.9–2.0 dex. With [Ba/Fe] > 1.9 dex and [Eu/Fe] $= 2.3$ dex, HE 0017+0055 is a CEMP-rs star. It appears to be a giant star below the tip of the red giant branch (RGB). The s-process pollution must therefore originate from mass transfer from a companion formerly on the AGB, now a carbon-oxygen white dwarf (WD). If the 384 d velocity variations are attributed to the WD companion, its orbit must be seen almost face-on, with $i \sim 2.3°$, because the mass function is very small: $f(M_1, M_2) = (6.1 \pm 1.1) \times 10^{-6}$ $M_\odot$. Alternatively, the WD orbital motion could be responsible for the long-term velocity variations, with a period of several decades. The 384 d variations should then be attributed either to a low-mass inner companion (perhaps a brown dwarf, depending on the orbital inclination), or to stellar pulsations. The latter possibility is made likely by the fact that similar low-amplitude velocity variations, with periods close to 1 yr, have been reported for other CEMP stars in a companion paper (Jorissen et al. 2015). A definite conclusion about the origin of the 384 d velocity variations should however await the detection of synchronous low-amplitude photometric variations.

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Empirical line lists and absorption cross sections for methane at high temperature

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Hot methane is found in many "cool" sub-stellar astronomical sources including brown dwarfs and exoplanets, as well as in combustion environments on Earth. We report on the first high-resolution laboratory absorption spectra of hot methane at temperatures up to 1200 K. Our observations are compared to the latest theoretical spectral predictions and recent brown dwarf spectra. The expectation that millions of weak absorption lines combine to form a continuum, not seen at room temperature, is confirmed. Our high-resolution transmittance spectra account for both the emission and absorption of methane at elevated temperatures. From these spectra, we obtain an empirical line list and continuum that is able to account for the absorption of methane in high temperature environments at both high and low resolution. Great advances have recently been made in the theoretical prediction of hot methane, and our experimental measurements highlight the progress made and the problems that still remain.

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High-resolution absorption cross sections of C_2H_6 at elevated temperatures

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Infrared absorption cross sections near 3.3 μm have been obtained for ethane, C_2H_6. These were acquired at elevated temperatures (up to 773 K) using a Fourier transform infrared spectrometer and tube furnace with a resolution of 0.005 cm^{-1}. The integrated absorption was calibrated using composite infrared spectra taken from the Pacific Northwest National Laboratory (PNNL). These new measurements are the first high-resolution infrared C_2H_6 cross sections at elevated temperatures.

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NGC 6778: Strengthening the link between extreme abundance discrepancy factors and central star binarity in planetary nebulæ

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We present new optical spectra of the nearby, bright, planetary nebula NGC 6778. The nebula has been known to emit strong recombination lines for more than 40 years but this is the first detailed study of its abundances. Heavy element abundances derived from recombination lines are found to exceed those from collisionally excited lines by a factor of ~ 20 in an integrated spectrum of the nebula, which is among the largest known abundance discrepancy factors. Spatial analysis of the spectra shows that the abundance discrepancy factor is strongly, centrally peaked, reaching ~ 40 close to the central star. The central star of NGC 6778 is known to be a short period binary, further strengthening the link between high nebular abundance discrepancy factors and central star binarity.

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The Penn State – Toruń Centre for Astronomy Planet Search stars. III. The evolved stars sample

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We intend to present complete spectroscopic analysis of 455 stars observed within the Penn State – Toruń Centre for Astronomy Planet Search (PTPS) with the High Resolution Spectrograph of the 9.2-m *Hobby–Eberly* Telescope. We will also present the total sample of 744 evolved stars of PTPS and discuss masses of stellar hosts in our and other surveys devoted to evolved planetary systems.
Stellar atmospheric parameters were determined through a strictly spectroscopic LTE analysis of equivalent widths of Fe I and Fe II lines. Rotational velocities were obtained from synthetic spectra fitting. Radial velocities were obtained from Gaussian function fitting to the cross-correlation function. We determined stellar masses, ages and luminosities via Bayesian analysis of theoretical isochrones. The radii were calculated either from derived masses and $\log g$ or from $T_{\rm eff}$ and luminosities.
We present basic atmospheric parameters ($T_{\rm eff}$, $\log g$, $v_{\rm t}$ and [Fe/H]), rotation velocities and absolute radial velocities as well as luminosities, masses, ages and radii for 402 stars (including 11 single-lined spectroscopic binaries), mostly subgiants and giants. For 272 of them we present parameters for the first time. For another 53 stars we present estimates of $T_{\rm eff}$ and $\log g$ based on photometric calibrations. More than half objects were found to be subgiants, there is also a large group of giants and a few stars appeared to be dwarfs. The results show that the presented sample is composed of stars with masses ranging from 0.52 to 3.21 $M_\odot$ of which 17 have masses ≥ 2.0 $M_\odot$. The radii of stars studied in this paper range from 0.66 to 36.04 $R_\odot$ with vast majority having radii between 2.0 and 4.0 $R_\odot$. They are generally less metal abundant than the Sun with median [Fe/H] $= -0.07$. For 62 stars in common with other planet searches we found a very good agreement in obtained stellar atmospheric parameters. We also present basic properties of the complete list of 744 stars that form the PTPS evolved stars sample. We examined stellar masses for 1255 stars in five other planet searches and found some of them likely to be significantly overestimated. Applying our uniformly determined stellar masses we confirm the apparent increase of companions masses for evolved stars, and we explain it, as well as lack of close-in planets with limited effective radial velocity precision for those stars due to activity.

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Masses and luminosities for 342 stars from the Penn State – Toruń Centre for Astronomy Planet Search

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We present revised basic stellar astrophysical parameters: masses, luminosities, ages and radii for 342 stars from Penn State – Toruń Centre for Astronomy Planet Search. Atmospheric parameters for 327 stars are available from Zieliński et al. (2012), for the remaining 15 objects we present also spectroscopic atmospheric parameters: effective temperatures, surface gravities and iron abundances. Spectroscopic atmospheric parameters were obtained with a standard spectroscopic analysis procedure, using ARES (Sousa et al. 2007) and MOOG (Sneden 1973) or TGVIT (Takeda et al. 2005) codes. To refine stellar masses, ages and luminosities we applied a Bayesian method based on Jørgensen & Lindegren (2005) formalism, modified by da Silva et al. (2006). The revised stellar masses for 342 stars and their uncertainties are generally lower than those presented in Zieliński et al. (2012). Atmospheric parameters for 13 objects are determined here for the first time.

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The physics of water masers observable with ALMA and SOFIA: Model predictions for evolved stars

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We present the results of models that were designed to study all possible water maser transitions in the frequency range 0–1.91 THz, with particular emphasis on maser transitions that may b e generated in evolved-star envelopes and observed with the ALMA and SOFIA telescopes. We used tens of thousands of radiative transfer models of both spin species of H_2O, spanning a considerable parameter space in number density, kinetic temperature and dust temperature. Results, in the form of maser optical depths, have been summarized in a master table, Table 6. Maser transitions identified in these models were grouped according to loci of inverted regions in the density/kinetic temperature plane, a property clearly related to the dominant mode of pumping. A more detailed study of the effect of dust temperature on maser optical depth enabled us to divide the maser transitions into three groups: those with both collisional and radiative pumping schemes (22, 96, 209, 321, 325, 395, 941 and 1486 GHz), a much larger set that are predominantly radiatively pumped, and another large group with a predominantly collisional pump. The effect of accelerative and decelerative velocity shifts of up to 5 km s^{-1} was found to be generally modest, with the primary effect of reducing computed maser optical depths. More subtle asymmetric effects, dependent on line overlap, include maximum gains offset from zero shift by > 1 km s^{-1}, but these effects were predominantly found under conditions of weak amplification. These models will allow astronomers to use multi-transition water maser observations to constrain physical conditions down to the size of individual masing clouds (size of a few astronomical units).

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The Chemical Abundances of Stars in the Halo (CASH) Project. III. A new classification scheme for carbon-enhanced metal-poor stars with s-process element enhancement

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We present a detailed abundance analysis of 23 elements for a newly discovered carbon-enhanced metal-poor (CEMP) star, HE 0414−0343, from the Chemical Abundances of Stars in the Halo (CASH) Project. Its spectroscopic stellar parameters are $T_{\rm eff}$ = 4863 K, $\log g$ = 1.25, $v_{\rm mic}$ = 2.20 km s^{-1}, and [Fe/H] = −2.24. Radial velocity measurements covering seven years indicate HE 0414−0343 to be a binary. HE 0414−0343 has [C/Fe] = 1.44 and is strongly enhanced in neutron-capture elements but its abundances cannot be reproduced by a solar-type s-process pattern alone. Traditionally, it could be classified as "CEMP-r/s" star. Based on abundance comparisons with AGB star nucleosynthesis models, we suggest a new physically-motivated origin and classification scheme for CEMP-s stars and the still poorly-understood CEMP-r/s. The new scheme describes a continuous transition between these two so-far distinctly treated subgroups: CEMP-sA, CEMP-sB, and CEMP-sC. Possible causes for a continuous transition include the number of thermal pulses the AGB companion underwent, the effect of different AGB star masses on their nucleosynthetic yields, and physics that is not well approximated in 1-D stellar models such as proton ingestion episodes and rotation. Based on a set of detailed AGB models, we suggest the abundance signature of HE 0414−0343 to have arisen from a $>$ 1.3 $M_\odot$ mass AGB star and a late-time mass transfer, that transformed HE 0414−0343 into a CEMP-sC star. We also find the [Y/Ba] ratio well parametrizes the classification and can thus be used to easily classify any future such stars.

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Multiwavelength transit observations of the candidate disintegrating planetesimals orbiting WD 1145+017

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We present multiwavelength, multi-telescope, ground-based follow-up photometry of the white dwarf WD 1145+017, that has recently been suggested to be orbited by up to six or more, short-period, low-mass, disintegrating planetesimals. We detect 9 significant dips in flux of between 10% and 30% of the stellar flux from our ground-based photometry. We observe transits deeper than 10% on average every $\sim$ 3.6 hr in our photometry. This suggests that WD 1145+017 is indeed being orbited by multiple, short-period objects. Through fits to the multiple asymmetric transits that we observe, we confirm that the transit egress timescale is usually longer than the ingress timescale, and that the transit duration is longer than expected for a solid body at these short periods, all suggesting that these objects have cometary tails streaming behind them. The precise orbital periods of the planetesimals in this system are unclear from the transit-times, but at least one object, and likely more, have orbital periods of $\sim$ 4.5 hours. We are otherwise unable to confirm the specific periods that have been reported, bringing into question the long-term stability of these periods. Our high precision photometry also displays low amplitude variations suggesting that dusty material is consistently passing in front of the white dwarf, either from discarded material from these disintegrating planetesimals or from the detected dusty debris disk. For the significant transits we observe, we compare the transit depths in the V- and R-bands of our multiwavelength photometry, and find no significant difference; therefore, for likely compositions the radius of single-size particles in the cometary tails streaming behind the planetesimals in this system must be $\sim$ 0.15 μm or larger, or $\sim$ 0.06 μm or smaller, with 2-σ confidence.

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A survey for hydroxyl in the THOR pilot region around W 43

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We report on observations of the hydroxyl radical (OH) within The H I, OH Recombination line survey (THOR) pilot region. The region is bounded approximately between Galactic coordinates $l = 29.^{\circ}2$ to $31.^{\circ}5$ and $b = -1.^{\circ}0$ to $+1.^{\circ}0$ and includes the high-mass star forming region W 43. We identify 103 maser sites, including 72 with 1612 MHz masers, 42 showing masers in either of the main line transitions at 1665 and 1667 MHz and four showing 1720 MHz masers. Most maser sites with either main-line or 1720 MHz emission are associated with star formation, whereas most of the 1612 MHz masers are associated with evolved stars. We find that nearly all of the main-line maser sites are co-spatial with an infrared source, detected by GLIMPSE. We also find diffuse OH emission, as well as OH in absorption towards selected unresolved or partially resolved sites. Extended OH absorption is found towards the well known star forming complex W 43 Main.

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Connecting the evolution of thermally pulsing asymptotic giant branch stars to the chemistry in their circumstellar envelopes – I. The case of hydrogen cyanide

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We investigate the formation of hydrogen cyanide (HCN) in the inner circumstellar envelopes of thermally pulsing asymptotic giant branch (TP-AGB) stars. A dynamic model for periodically shocked atmospheres, which includes an extended chemo-kinetic network, is for the first time coupled to detailed evolutionary tracks for the TP-AGB phase computed with the COLIBRI code. We carried out a calibration of the main shock parameters (the shock formation radius and the effective adiabatic index) using the circumstellar HCN abundances recently measured for a populous sample of pulsating TP-AGB stars. Our models recover the range of the observed HCN concentrations as a function of the mass-loss rates, and successfully reproduce the systematic increase of HCN moving along the M–S–C chemical sequence of TP-AGB stars, that traces the increase of the surface C/O ratio. The chemical calibration brings along two

important implications: i) the first shock should emerge very close to the photosphere, and ii) shocks are expected to have a dominant isothermal character in the denser region close to the star (within $\sim$ 3–4 $R_\star$), implying that radiative processes should be quite efficient. Our analysis also suggests that the HCN concentrations in the inner circumstellar envelopes are critically affected by the H–H_2 chemistry during the post-shock relaxation stages.

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Mass-loss rate by the Mira in the symbiotic binary V1016 Cygni from Raman scattering

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The mass-loss rate from Mira variables represents a key parameter in our understanding of their evolutionary tracks. We introduce a method for determining the mass-loss rate from the Mira component in D-type symbiotic binaries via the Raman scattering on atomic hydrogen in the wind from the giant. Using our method, we investigated Raman He II λ1025 $\rightarrow$ λ6545 conversion in the spectrum of the symbiotic Mira V1016 Cyg. We determined its efficiency, $\eta = 0.102$, 0.148, and the corresponding mass-loss rate, $\dot{M} = 2.0^{+0.1}_{-0.2} \times 10^{-6}$, $2.7^{+0.2}_{-0.1} \times 10^{-6}$ $M_\odot$ yr^{-1}, using our spectra from 2006 April and 2007 July, respectively. Our values of $\dot{M}$ that we derived from Raman scattering are comparable with those obtained independently by other methods. Applying the method to other Mira–white dwarf binary systems can provide a necessary constraint in the calculation of asymptotic giant branch (AGB) evolution.

Published in The Astrophysical Journal
Available from arXiv:1510.08356

Conference Paper

A window on the efficiency of the s-process in AGB stars: chemical abundances of n-capture elements in the planetary nebula NGC 3918

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The chemical content of the planetary nebula NGC 3918 is investigated through deep, high-resolution ($R \sim 40\,000$) UVES at VLT spectrophotometric data. We identify and measure more than 750 emission lines, making ours one of the deepest spectra ever taken for a planetary nebula. Among these lines we detect very faint lines of several neutron-capture elements (Se, Kr, Rb, and Xe), which enable us to compute their chemical abundances with unprecedented accuracy, thus constraining the efficiency of the s-process and convective dredge-up in the progenitor star of NGC 3918.

Poster contribution, published in EWASS 2015 Special Session "AGB stars: a key ingredient in the understanding and interpretation of stellar populations", Memorie della Società Astronomica Italiana
Available from arXiv:1510.04548

Review Paper

Chemical abundances from planetary nebulæ in local spiral galaxies

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While the chemical abudances observed in bright planetary nebulæ in local spiral galaxies are less varied than their counterparts in dwarfs, they provide new insight. Their helium abundances are typically enriched by less than 50% compared to the primordial abundance. Nitrogen abundances always show some level of secondary enrichment, but the absolute enrichment is not extreme. In particular, type I PNe are rare among the bright PNe in local spirals. The oxygen and neon abundances are very well correlated and follow the relation between these abundances observed in star-forming galaxies, implying that either the progenitor stars of these PNe modify neither abundance substantially or that they modify both to maintain the ratio (not predicted by theory). According to theory, these results imply that the progenitor stars of bright PNe in local spirals have masses of about 2 $M_{\odot}$ or less. If so, the progenitors of these PNe have substantial lifetimes that allow us to use them to study the recent history of their host galaxies, including gravitational interactions with their neighbours. Areas that require further study include the systematic differences observed between spectroscopy obtained through slits and fibres, the uncertainties assigned to chemical abundances, including effects due to ionization correction factors, and the physics that gives rise to the PN luminosity function. Indeed, so long as we lack an understanding of how the last arises, our ability to use bright PNe as probes to understand the evolution of their host galaxies will remain limited.

Published in Highlights of Astronomy, the proceedings of FM4 at the IAU GA XXIX
Available from arXiv:1509.08537

Job Advert

Doctoral student in Astronomy and Astrophysics High-resolution, infrared stellar spectroscopy

Research in stellar spectroscopy has a long tradition in Sweden and has recently been fueled by and benefitted from a rapid development of telescopes and in instrumentation. The research group at Lund Observatory regularly uses the largest telescopes around the world, such as the American Keck, Gemini N & S, KPNO, IRTF, and McDonald Observatory telescopes and the European VLT and NOT telescopes.

The funding of the Ph.D. position is based on a Swedish research council grant in the field of galaxy formation and evolution: 'The Origin of the Milky Way and its Bulge: Spectroscopic Investigations of Stellar Populations in the Galactic Centre Region'. The Ph.D. student will preferably work within this project, which already has been very successful in acquiring a wealth of data, under tough competition.

Job assignment

The Ph.D. student will work on projects including the development of methodology in the field of high-resolution optical/infrared spectroscopy of stars. The research activity will consist of the collection, analysis and interpretation of observational data, and the modeling of these. Furthermore, theoretical investigations needed for the interpretations will be encouraged. The suggested main research project deals with analyzing the chemical content of red giant stars in order to investigate the origin and evolution of the huge, central structure of the Milky Way, the Bulge. Usage of

world-leading observatories and collaboration in an international network is anticipated. Knowledge of stellar atmospheres, radiation transport, and stellar spectroscopy is a merit.

Eligibility/Entry requirements

The grant is open to students of all nationalities who, at the time of starting the Ph.D. studies, have obtained a Masters degree in astronomy, physics, or engineering physics, or in other ways obtained the equivalent qualifications. In case of uncertainty concerning the applicant's eligibility, it is advisable to contact the department for clarification. The discipline curriculum for postgraduate studies in Astronomy and Astrophysics is found at http://www.science.lu.se/sites/science.lu.se/files/syllabi_astronomy.pdf. Good knowledge in spoken and written English is required. For more information on our Ph.D. programme, see http://www.astro.lu.se/Education/FU/.

Contact: Nils Ryde, Senior university lecturer, +4646-2221574

Reference number PA2015/2770

Closing date: November 2, 2015
Starting date: summer 2016

Apply Online (https://lu.mynetworkglobal.com/en/what:job/jobID:74381/)

See also https://lu.mynetworkglobal.com/en/what:job/jobID:74381/

Announcements

Evolved stars get-together 2016

We hereby announce the "Evolved stars get-together 2016", a meeting targeted at Ph.D. students and young postdocs in the field of evolved stars.

The goal of the meeting is to create a comfortable and informal climate to encourage discussions about ongoing research, and to strengthen the European network of young evolved-star researchers.

The get-together is open to scientists from all fields of evolved-star research, from post-main sequence evolution of both low and high-mass stars, to planetary nebulæ and super nova remnants. The final content of the meeting will be directly dependent on the participants' current research.

In addition to providing direct input and help for one's ongoing research, the get-togethers have, in the past, demonstrated a positive discussion attitude and have helped build a sense of community between Europe's young researchers in evolved stars.

The meeting will be held on the main campus of Chalmers University of Technology in Gothenburg, Sweden, January 27–29, 2016. This will be the 5^{th} get-together in a series of meetings since 2013.

In order to ensure an informal atmosphere, the get-together is limited to 25 participants.

The deadline for registration is November 20, 2016. Registration is free of charge.

For more information and registration, please visit:

https://sites.google.com/site/evolvedstarsgettogether/

We look forward to hearing from you!

With kind regards,

Matthias Maercker
Elvire De Beck
Theo Khouri
Robin Lombaert

See also https://sites.google.com/site/evolvedstarsgettogether/

Electron Capture Supernovæ and Super-AGB star workshop

Dear Colleagues,

We would like to announce the Joint Institute for Nuclear Astrophysics (JINA) workshop on Electron Capture Supernovæ (ECSNe) & Super-AGB Stars to be held February 1–5, 2016 at Monash University, Melbourne, Australia. This workshop aims to bring together Australian and international experts from stellar evolution, supernova theory, stellar spectroscopy, hydrodynamics, and nuclear physics with expected topics including:

- single and binary super-AGB star evolution
- population synthesis & ECSNe rate predictions
- convective URCA phase
- C and O/Ne flame propagation
- electron capture supernova models
- s/p/r/iprocess nucleosynthesis
- spectroscopy and GCE role of ECSNe at low metallicity
- ECSNe from Pop III stars
- evidence for ECSNe from a) light curves, b) SN remnants c) neutron star masses
- massive white dwarf formation and the WD/SN boundary

Registration is free and now open and we are able to offer limited financial support for students.

We hope to see you in Melbourne next February!

The Organising Committee
Carolyn Doherty, Alexander Heger, John Lattanzio and Bernhard Müller

See also http://users.monash.edu.au/∼cdoherty/EC-SN-2016/

CLOUDY: Emission lines in Astrophysics, from gaseous nebulæ to quasars
A Symposium to honor Gary Ferland
México City, 2016 August 8–12

The purpose of this symposium is to celebrate the scientific career of Gary Ferland. A substantial fraction of his research career has been devoted to the development of the code CLOUDY and its applications to the study of the interstellar medium.

CLOUDY has been applied to a wide variety of astronomical environments including photodissociation regions, molecular clouds, H II regions, planetary nebulæ, novæ and supernova remnants, active galactic nuclei, and starburst galaxies. We will review those areas of astrophysics where the impact of CLOUDY has been important and we will try to glance into the future of interstellar medium research. The proposed program is aimed at the most important issues related to the modeling of emission line interpretation under different astrophysical regimes. In particular the topics to cover would be:

- •Modeling Gaseous Nebulæ
- •Atomic Data for Astrophysics
- •Active Galactic Nuclei Emission
- •Interstellar and circumstellar matter
- •Novæ and Supernova Remnants
- •H II Regions
- •Planetary Nebulæ
- •Intergalactic Medium
- •Photodissociation Regions
- •Extending modelling capabilities

Scientific Organizing Commitee (SOC):

- Bozena Czerny
- Andrew Fabian
- William Henney
- Frances Keenan
- Ajit K. Kembhav
- C. Robert O'Dell (co-chair)
- Manuel Peimbert (co-chair)
- Grażyna Stasińska
- Thomas Troland
- Tiangu Wang
- Martin Ward

Local Organizing Committee (LOC):

- Rafael Costero
- Gloria Delgado Inglada
- Christophe Morisset
- Antonio Peimbert
- Miriam Peña
- Silvia Torres-Peimbert

The preregistration is now open until 31 of December 2015. Notice that the number of participants is limited. The SOC will decide which type of presentation you will be able to give, and will communicate the result by the end of January. We very much hope that you will be able to attend the conference.

You will find further details on the conference website.

See also https://sites.google.com/a/astro.unam.mx/cloudy2016/