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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

Happy New Year! (Well, on some calendars.) It is our pleasure to present you the 162$^{\rm nd}$ issue of the AGB Newsletter.

If you know of any brilliant candidate for a Ph.D. studentship, there is a great opportunity at Macquarie University.

The next issue is planned to be distributed on the 1$^{\rm st}$ of February 2011.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

If water exists in the wind acceleration zone of carbon stars, we should see 22-GHz masers in them

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

Refereed Journal Papers

Period–Magnitude relation of Mira-like variables in the Large Magellanic Cloud as a tool to understand circumstellar extinction

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Near- to mid-infrared period-magnitude relations and also the period–bolometric luminosity relation of OGLE-III Mira-like variables in the LMC are derived. The relations have a kink, and the period at which the break occurs is quantitatively obtained. There are many Mira-like variables whose fluxes at the optical and the near-infrared wavebands are fainter than the ones predicted by the period–magnitude relations. The deviation is due to the circumstellar extinction, and the amount of the deviation is found to be strongly correlated with near-infrared colors. The empirical formulae relating the amount of the deviation and the near-infrared colors are derived. These relations are useful to accurately calculate the distances to the dusty Mira-like variables, because the dimmed fluxes due to the circumstellar extinction can be estimated. In a manner analogous to the interstellar extinction law, the ratios of deviations at any two different wavebands are calculated. The ratios are found to change with the pulsation period, indicating that the dust properties are subject to change as Mira-like variables evolve.

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New census of the variable star population in the Globular Cluster NGC 2419

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We present B, V and I CCD light curves for 101 variable stars belonging to the globular cluster NGC 2419, 60 of which are new discoveries, based on datasets obtained at the TNG, SUBARU and HST telescopes. The sample includes 75 RR Lyrae stars (of which 38 RRab, 36 RRc and one RRd), one Population II Cepheid, 12 SX Phoenicis variables, 2 δ Scuti stars, 3 binary systems, 5 long-period variables, and 3 variables of uncertain classification.
The pulsation properties of the RR Lyrae variables are close to those of Oosterhoff type II clusters, consistent with the low metal abundance and the cluster horizontal branch morphology, disfavoring (but not totally ruling out) an extragalactic hypotesis for the origin of NGC 2419. The observed properties of RR Lyrae and SX Phoenicis stars are used to estimate the cluster reddening and distance, using a number of different methods. Our final value is μ_0 (NGC 2419) $= 19.71 \pm 0.08$ mag ($D = 87.5 \pm 3.3$ kpc), with $E(B-V) = 0.08 \pm 0.01$ mag, [Fe/H] $= -2.1$ dex in the Zinn & West metallicity scale, and a value of M_V that sets μ_0 (LMC) $= 18.52$ mag. This value is in good agreement with most recent literature estimates of the distance to NGC 2419.

Accepted for publication in Astronomical Journal
Available from arXiv:1011.5398

H I observations of the Asymptotic Giant Branch Star X Herculis: Discovery of an extended circumstellar wake superposed on a compact High-Velocity Cloud

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We report H I 21-cm line observations of the asymptotic giant branch (AGB) star X Her obtained with the Robert C. Byrd Green Bank Telescope (GBT) and the Very Large Array (VLA). We have unambiguously detected H I emission associated with the circumstellar envelope of the star, with a mass totaling $M_{\rm HI} \approx 2.1 \times 10^{-3}$ M$_\odot$. The H I distribution exhibits a head-tail morphology, similar to those previously observed around the AGB stars Mira and RS Cnc. The tail is elongated along the direction of the star's space motion, with a total extent of $\gtrsim$6.0′ (0.24 pc) in the plane of the sky. We also detect a systematic radial velocity gradient of $\sim$6.5 km s^{-1} across the H I envelope. These results are consistent with the H I emission tracing a turbulent wake that arises from the motion of a mass-losing star through the interstellar medium (ISM). GBT mapping of a $2^\circ \times 2^\circ$ region around X Her reveals that the star lies (in projection) near the periphery of a much larger H I cloud that also exhibits signatures of interaction with the ISM. The properties of the cloud are consistent with those of compact high-velocity clouds. Using ^{12}CO J=1–0 observations, we have placed an upper limit on its molecular gas content of $N_{\rm H2} < 1.3 \times 10^{20}$ cm^{-2}. Although the distance to the cloud is poorly constrained, the probability of a chance coincidence in position, velocity, and apparent position angle of space motion between X Her and the cloud is extremely small, suggesting a possible physical association. However, the large H I mass of the cloud ($\gtrsim$2.4 M$_\odot$) and the blueshift of its mean velocity relative to X Her are inconsistent with an origin tied directly to ejection from the star.

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and from http://www.haystack.mit.edu/hay/staff/lmatthew/matthews_XHer.pdf

Turbulent cells in stars: I. Fluctuations in kinetic energy

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Three-dimensional (3D) hydrodynamic simulations of shell oxygen burning (Meakin & Arnett 2007) exhibit bursty, recurrent fluctuations in turbulent kinetic energy. These are shown to be due to a general instability of the convective cell, requiring only a localized source of heating or cooling. Such fluctuations are shown to be suppressed in simulations of stellar evolution which use mixing-length theory (MLT).
Quantitatively similar behavior occurs in the model of a convective roll (cell) of (Lorenz 1963), which is known to have a strange attractor that gives rise to chaotic fluctuations in time. Study of simulations suggests that the Lorenz convective roll may approximate the behavior of a cell in the *large scale* convective flow. Other flow patterns are also of interest (Chandrasekhar 1961); here we examine some implications of this simplest case, which is not a unique solution, but may be representative. A direct derivation of the Lorenz equations from the general fluid-dynamic equations for stars is presented in the Appendix, strengthening the identification and providing connections to astrophysics.
Using the Lorenz model as representative of a convective cell, a multiple-cell model of a convective layer gives luminosity fluctuations which are suggestive of irregular variables (red giants and supergiants, Schwarzschild 1975). This "τ-mechanism" is a new source for stellar variability, and one closely related to intermittency in turbulence.

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Red supergiant stars in the Large Magellanic Cloud. I. The Period–Luminosity relation

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From previous samples of red supergiants (RSGs) by various groups, 191 objects are assembled to compose a large sample of RSG candidates in LMC. For 189 of them, the identity as an RSG is verified by their brightness and color indexes in several near- and mid-infrared bands related to the Two Micron All Sky Survey (2MASS) JHK_s bands and the *Spitzer*/IRAC and *Spitzer*/MIPS bands. From the visual time-series photometric observations by the ASAS and MACHO projects which cover nearly 8–10 years, the period and amplitude of light variation are analyzed carefully using both the phase dispersion minimization and Period04 methods. According to the properties of light variation, these objects are classified into five categories: (1) 20 objects are saturated in photometry or located in crowded stellar field with poor photometric results, (2) 35 objects with too complex variation to have any certain period, (3) 23 objects with irregular variation, (4) 16 objectswith semi-regular variation, and (5) 95 objects with long secondary period (LSP) among which 31 have distinguishable short period and 51 have a long period shorter than 3000 days that can be determined with reasonable accuracy. For the semi-regular variables and the LSP variables with distinguishable short period, the period–luminosity (P–L) relation is analyzed in the visual, near-infrared, and mid-infrared bands. It is found that the P–L relation is tight in the infrared bands such as the 2MASS JHK_s bands and the *Spitzer*/IRAC bands, in particular in the *Spitzer*/IRAC [3.6] and [4.5] bands; meanwhile, the P–L relation is relatively sparse in the V band which may be caused by the inhomogeneous interstellar extinction. The results are compared with other P–L relationships for RSGs and the P–L sequences of red giants in LMC.

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Maser properties of the enigmatic IRAS Source 19312+1950

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The IRAS source, 19312+1950, exhibits SiO maser emission, which is predominantly detected in evolved stars enshrouded by a cold molecular envelope. In fact, the mojority of the observational properties of IRAS 19312+1950 is consistent with the nature of an asymptotic giant branch (AGB) star or post-AGB star. Interestingly, however, some of the observational properties cannot be readily explained within the standard scheme of stellar evolution, and those are rather reminiscent of young stellar objects. In the present research we considered the evolutionary status of IRAS 19312+1950 as revealed by the VLBI and MERLIN observations in SiO, H_2O and OH maser lines. The double-peaked profile of the 22-GHz H_2O maser line is clearly detected, with the emission regions of its red and blue-shifted components separately located, leaving a space of about 10.9 mas between them. The kinematic properties of H_2O maser emission region appear to be more consistent with a bipolar flow rather than other interpretations such as the Keplerian rotation of a disk. The red-shifted component of the SiO maser emission, which exhibits a double-peak profile in previous single-dish observations, is clearly detected in the present interferometry, while the 1612-MHz OH maser line exhibits a complicated line profile consisting of a single strong peak and many weak, high-velocity spikes. The structure of OH maser emission region is partially resolved, and the kinematic properties of the OH maser emission region are reminiscent observations of a spherically expanding shell, even though the evidence is scant. Collectively, the maser observations described here provide additional support for the evolved star hypothesis for IRAS 19312+1950.

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Thermohaline mixing and its role in the evolution of carbon and nitrogen abundances in globular cluster red giants: The test case of Messier 3

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We review the observational evidence for extra mixing in stars on the red giant branch (RGB) and discuss why thermohaline mixing is a strong candidate mechanism. We recall the simple phenomenological description of thermohaline mixing, and aspects of mixing in stars in general. We use observations of M 3 to constrain the form of the thermohaline diffusion coefficient and any associated free parameters. This is done by matching [C/Fe] and [N/Fe] along the RGB of M 3. After taking into account a presumed initial primordial bimodality of [C/Fe] in the CN-weak and CN-strong stars our thermohaline mixing models can explain the full spread of [C/Fe]. Thermohaline mixing can produce a significant change in [N/Fe] as a function of absolute magnitude on the RGB for initially CN-weak stars, but not for initially CN-strong stars, which have so much nitrogen to begin with that any extra mixing does not significantly affect the surface nitrogen composition.

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Mid-infrared observations of Planetary Nebulae detected in the GLIMPSE 3D Survey

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We present mapping, profiles and photometry for 24 planetary nebulae (PNe) detected in the GLIMPSE 3D mid-infrared (MIR) survey of the Galactic plane. The PNe show many of the properties observed in previous studies of these sources, including evidence for longer wave emission from outside of the ionised zones, a likely consequence of emission from polycyclic aromatic hydrocarbons (PAHs) within the nebular photo-dissociation regimes (PDRs). We also note variations in 5.8/4.5 and 8.0/4.5 μm flux ratios with distance from the nuclei; present evidence for enhanced MIR emission in the halos of the sources; and note evidence for variations in colour with nebular evolution.

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Criss–cross mapping BD +30 3639: a new kinematic analysis technique

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We introduce a new method to analyze kinematic proper motion data. The method is called "criss–cross" mapping. It emphasizes regions where proper motion vector extensions cross or converge. From a superposition of lines through the vectors a map is generated which helps to interpret the kinematic data. The new mapping technique is applied to the young planetary nebula BD +30 3639. The data are more than 200 internal proper motion measurements from Li, Harrington & Borkowski (2002). From the criss-cross mapping of BD +30 3639, we conclude that the kinematic

center is approximately 0.5″ off-set to the South–East from the central star. The mapping also shows evidence for a non-homologous expansion of the nebula that is consistent with a disturbance due to the bipolar molecular bullets.

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ETHOS 1: A high-latitude planetary nebula with jets forged by a post common envelope binary central star

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We report on the discovery of ETHOS 1 (PN G 068.1+11.0), the first spectroscopically confirmed planetary nebula (PN) from a survey of the SuperCOSMOS Science Archive for high-latitude PNe. ETHOS 1 stands out as one of the few PNe to have both polar outflows (jets) travelling at 120 ± 10 km s^{-1} and a close binary central star. The lightcurve observed with the Mercator telescope reveals an orbital period of 0.535 days and an extremely large amplitude (0.816 mag) due to irradiation of the companion by a very hot pre-white dwarf. ETHOS 1 further strengthens the long suspected link between binary central stars of planetary nebulae (CSPN) and jets. INT IDS and VLT FORS spectroscopy of the CSPN reveals weak N III, C III and C IV emission lines seen in other close binary CSPN and suggests many CSPN with these weak emission lines are misclassified close binaries. We present VLT FORS imaging and Manchester Echelle Spectrometer long slit observations from which a kinematic model of the nebula is built. An unusual combination of bipolar outflows and a spherical nebula conspire to produce an X-shaped appearance. The kinematic age of the jets (1750 ± 250 yr kpc^{-1}) are found to be older than the inner nebula (900 ± 100 yr kpc^{-1}) consistent with previous studies of similar PNe. Emission line ratios of the jets are found to be consistent with reverse-shock models for fast low-ionisation emitting regions (FLIERS) in PNe. Further large-scale surveys for close binary CSPN will be required to securely establish whether FLIERS are launched by close binaries.

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VLT/X-shooter spectroscopy of a dusty Planetary Nebula discovered with *Spitzer*/IRS

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As part of a mid-infrared spectroscopic survey of young stars with the *Spitzer* Space Telescope, an unclassified red emission line object was discovered. Based on its high ionization state indicated by the Spitzer spectrum, this object

could either be a dusty Supernova Remnant (SNR) or a Planetary Nebula (PN). In this research note, the object is classified and the available spectroscopic data are presented to the community for further analysis. UV/optical/NIR spectra were obtained during the science verification run of the VLT/X-shooter. A large number of emission lines are identified allowing the determination of the nature of this object. The presence of strong, narrow ($\Delta v \sim 8$–74 km s^{-1}) emission lines, combined with very low line ratios of, e.g., [N II]/Hα and [S II]/Hα show that the object is a Planetary Nebula (PN) that lies at an undetermined distance behind the Serpens Molecular Cloud. This illustrates the potential of X-shooter as an efficient tool for constraining the nature of faint sources with unknown spectral properties or colors.

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Galaxies M 32 and NGC 5102 confirm a near-infrared spectroscopic chronometer

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We present near infrared (NIR) IRTF/SpeX spectra of the intermediate-age galaxy M 32 and the post-starburst galaxy NGC 5102. We show that features from thermally-pulsing asymptotic giant branch (TP-AGB) and main sequence turn-off (MSTO) stars yield similar ages to those derived from optical spectra. The TP-AGB can dominate the NIR flux of a coeval stellar population between ~ 0.1 and ~ 2 Gyr, and the strong features of (especially C-rich) TP-AGB stars are useful chronometers in integrated light studies. Likewise, the Paschen series in MSTO stars is strongly dependent on age and is an indicator of a young stellar component in integrated spectra. We define four NIR spectroscopic indices to measure the strength of absorption features from both C-rich TP-AGB stars and hydrogen features in main sequence stars, in a preliminary effort to construct a robust chronometer that probes the contributions from stars in different evolutionary phases. By comparing the values of the indices measured in M 32 and NGC 5102 to those in the Maraston (2005) stellar population synthesis models for various ages and metallicities, we show that model predictions for the ages of the nuclei of M 32 and NGC 5102 agree with previous results obtained from integrated optical spectroscopy and CMD analysis of the giant branches. The indices discriminate between an intermediate age population of ~ 3–4 Gyr, a younger population of < 1 Gyr, and can also detect the signatures of very young (< 100 Myr) populations.

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Available from arXiv:1012.2807

Stellar metallicities beyond the Local Group: the potential of J-band spectroscopy with extremely large telescopes

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We present simulated J-band spectroscopy of red giants and supergiants with a 42m European Extremely Large Telescope (E-ELT), using tools developed toward the EAGLE Phase A instrument study. The simulated spectra are used to demonstrate the validity of the 1.15–1.22 μm region to recover accurate stellar metallicities from Solar and metal-poor (one tenth Solar) spectral templates. From tests at spectral resolving powers of four and ten thousand, we require continuum signal-to-noise ratios in excess of 50 (per two-pixel resolution element) to recover the input metallicity to within 0.1 dex. We highlight the potential of direct estimates of stellar metallicites (over the range $-1 <$ [Fe/H] < 0) of red giants with the E-ELT, reaching out to distances of ~ 5 Mpc for stars near the tip of the red giant branch. The same simulations are also used to illustrate the potential for quantitative spectroscopy of red supergiants beyond the Local Volume to tens of Mpc. Calcium triplet observations in the I-band are also simulated

to provide a comparison with contemporary techniques. Assuming the EAGLE instrument parameters and simulated performances from adaptive optics, the J-band method is more sensitive in terms of recovering metallicity estimates for a given target. This appears very promising for ELT studies of red giants and supergiants, offering a direct metallicity tracer at a wavelength which is less afffected by extinction than shortward diagnostics and, via adaptive optics, with better image quality.

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High-resolution spectroscopic observations of a new CH subgiant star: BD $-03°366$

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This work aims to report the discovery of a new CH subgiant star BD $-03°3668$ with significant overabundance of the elements created by the s-process nucleosynthesis, such as barium and lead. Its atmospheric parameters and abundance pattern were determined employing the local-thermodynamic-equilibrium model atmospheres of Kurucz using the spectral analysis code MOOG. Due to the low luminosity of this star, the s-process overabundance is better explained by mass-transfer from an AGB star in the past.

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Turbulent mixing and layer formation in double-diffusive convection: 3D numerical simulations and theory

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Double-diffusive convection, often referred to as semi-convection in astrophysics, occurs in thermally and compositionally stratified systems which are stable according to the Ledoux-criterion but unstable according to the Schwarzchild criterion. This process has been given relatively little attention so far, and its properties remain poorly constrained. In this paper, we present and analyze a set of three-dimensional simulations of this phenomenon in a Cartesian domain under the Boussinesq approximation. We find that in some cases the double-diffusive convection saturates into a state of homogeneous turbulence, but with turbulent fluxes several orders of magnitude smaller than those expected from direct overturning convection. In other cases the system rapidly and spontaneously develops closely-packed thermo-compositional layers, which later successively merge until a single layer is left. We compare the output of our simulations with an existing theory of layer formation in the oceanographic context, and find very good agreement between the model and our results. The thermal and compositional mixing rates increase significantly during layer formation, and increase even further with each merger. We find that the heat flux through the staircase is a simple function of the layer height. We conclude by proposing a new approach to studying transport by double-diffusive convection in astrophysics.

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Dust and chemical abundances of the Sagittarius dwarf galaxy Planetary Nebula Hen 2-436

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We have estimated elemental abundances of the planetary nebula Hen 2-436 in the Sagittarius (Sgr) spheroidal dwarf galaxy using ESO/VLT FORS2, Magellan/MMIRS, and *Spitzer*/IRS spectra. We have detected candidates of fluorine [F II]λ4790, krypton [Kr III]λ6826, and phosphorus [P II]λ7875 lines and successfully estimated the abundances of these elements ([F/H]=+1.23, [Kr/H]=+0.26, [P/H]=+0.26) for the first time. These elements are known to be synthesized by neutron capture process in the He-rich intershell during the thermally pulsing AGB phase. We present a relation between C, F, P, and Kr abundances among PNe and C-rich stars. The detections of F and Kr in Hen 2-436 support the idea that F and Kr together with C are synthesized in the same layer and brought to the surface by the third dredge-up. We have detected N II and O II optical recombination lines (ORLs) and derived the N^{2+} and O^{2+} abundances. The discrepancy between the abundance derived from the oxygen ORL and that derived from the collisionally excited line is >1 dex. To investigate the status of the central star of the PN, nebula condition, and dust properties, we construct a theoretical spectral energy distribution (SED) model to match the observed SED with Cloudy. By comparing the derived luminosity and temperature of the central star with theoretical evolutionary tracks, we conclude that the initial mass of the progenitor is likely to be $\sim$ 1.5–2.0 $M_\odot$ and the age is $\sim$ 3000 yr after the AGB phase. The observed elemental abundances of Hen 2-436 can be explained by a theoretical nucleosynthesis model with a star of initial mass 2.25 $M_\odot$, $Z = 0.008$ and LMC compositions. We have estimated the dust mass to be 2.9×10^{-4} $M_\odot$ (amorphous carbon only) or 4.0×10^{-4} $M_\odot$ (amorphous carbon and PAH). Based on the assumption that most of the observed dust is formed during the last two thermal pulses and the dust-to-gas mass ratio is 5.58×10^{-3}, the dust mass-loss rate and the total mass-loss rate are $< 3.1 \times 10^{-8}$ $M_\odot$ yr^{-1} and $< 5.5 \times 10^{-6}$ $M_\odot$ yr^{-1}, respectively. Our estimated dust mass-loss rate is comparable to a Sgr dwarf galaxy AGB star with similar metallicity and luminosity.

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Radiative hydrodynamics simulations of red supergiant stars. III. Spectro-photocentric variability, photometric variability, and consequences on Gaia measurements

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Context. It has been shown that convection in red supergiant stars (RSG) gives rise to large granules causing surface inhomogeneities together with shock waves in the photosphere. The resulting motion of the photocenter (on time

scales ranging from months to years) could possibly have adverse effects on the parallax determination with Gaia.
Aims. We explore the impact of the granulation on the photocentric and photometric variability. We quantify these effects in order to better characterize the error possibly altering the parallax.
Methods. We use 3D radiative-hydrodynamics (RHD) simulations of convection with CO5BOLD and the post-processing radiative transfer code OPTIM3D to compute intensity maps and spectra in the Gaia G band [325–1030 nm].
Results. We provide astrometric and photometric predictions from 3D simulations of RSGs that are used to evaluate the possible degradation of the astrometric parameters of evolved stars derived by Gaia. We show in particular from RHD simulations that a supergiant like Betelgeuse exhibits a photocentric noise characterised by a standard deviation of the order of 0.1 AU. The number of bright giant and supergiant stars whose Gaia parallaxes will be altered by the photocentric noise ranges from a few tens to several thousandths, depending on the poorly known relation between the size of the convective cells and the atmospheric pressure scale height of supergiants, and to a lower extent, on the adopted prescription for galactic extinction. In the worst situation, the degradation of the astrometric fit due to the presence of this photocentric noise will be noticeable up to about 5 kpc for the brightest supergiants. Moreover, parallaxes of Betelgeuse-like supergiants are affected by a error of the order of a few percents. We also show that the photocentric noise, as predicted by the 3D simulation, does account for a substantial part of the supplementary "cosmic noise" that affects *Hipparcos* measurements of Betelgeuse and Antares.

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Clearing the gas from globular clusters & dwarf spheroidals with classical novae

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Observations of the intra-cluster medium (ICM) in galactic globular clusters (GCs) show a systematic deficiency in ICM mass as compared to that expected from accumulation of stellar winds in the time available between galactic plane crossings. In this paper, we re-examine the original hypothesis of Scott & Durisen that hydrogen-rich explosions on accreting white dwarfs, classical novae (CNe), will sweep out the ICM from the cluster more frequently than galactic plane crossings. From the CNe rate and stellar mass loss rate, this clearing mechanism predicts that ≈ 0.03 $M_\odot$ should be present in $\leq 10^5$ $M_\odot$ GCs. We model the expanding remnant made from the 10^{-4} $M_\odot$ nova ejecta and show that it escapes long before it has cooled. We discuss the few positive ICM measurements and use a Monte Carlo simulation of the accumulation and CNe recurrence times to reveal the possible variance in the ICM masses for the higher mass ($> 5 \times 10^5$ $M_\odot$) GCs. We find that nova shells are effective at clearing the ICM in low-mass GCs ($\leq 10^5$ $M_\odot$), whereas higher mass clusters may experience a quiescent time between novae long enough to prevent the next nova shell from escaping. The nova clearing mechanism will also operate in ultra-faint Milky Way satellites, where many upper limits on gas masses are available.

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Water in IRC +10 216: a genuine formation process by shock-induced chemistry in the inner wind

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Context: The presence of water in the wind of the extreme carbon star IRC +10 216 has been confirmed with the

Herschel telescope. The regions where the high-J H_2O lines have been detected are close to the star at radii $r < 15$ $R_\star$.
Aims:We investigate the formation of water and related molecules in the periodically-shocked inner layers of IRC +10 216 where dust also forms and accelerates the wind.
Methods: We describe the molecular formation by a chemical kinetic network involving carbon-and oxygen-based molecules. We then apply this network to the physical conditions pertaining to the dust-formation zone which experiences the passage of pulsation-driven shocks between 1 and 5 $R_\star$. We solve for a system of stiff, coupled, ordinary, and differential equations.
Results: Non-equilibrium chemistry prevails in the dust-formation zone. H_2O forms quickly above the photosphere from the synthesis of hydroxyl OH induced by the thermal fragmentation of CO in the hot post-shock gas. The derived abundance with respect to H_2 at 5 $R_\star$ is 1.4×10^{-7}, which excellently agrees with the values derived from *Herschel* observations. The non-equilibrium formation process of water will be active whatever the stellar C/O ratio, and H_2O should then be present in the wind acceleration zone of all stars on the Asymptotic Giant Branch.

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Are proto-planetary nebulae shaped by a binary? Results of a long-term radial velocity study

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The shaping of the nebula is currently one of the outstanding unsolved problems in planetary nebula (PN) research. Several mechanisms have been proposed, most of which require a binary companion. However, direct evidence for a binary companion is lacking in most PNs. We have addressed this problem by obtaining precise radial velocities of seven bright proto-planetary nebulae (PPNs), objects in transition from the asymptotic giant branch to the PN phases of stellar evolution. These have F–G spectral types and have the advantage over PNs of having more and sharper spectral lines, leading to better precision. Our observations were made in two observing intervals, 1991–1995 and 2007–2009, and we have included in our analysis some additional published and unpublished data. Only one of the PPNs, IRAS 22272+5435, shows a long-term variation that might be attributable to a binary companion, and very preliminary binary parameters are determined ($P \sim 34$ yr). Selection effects are also discussed. These results set significant restrictions on the range of possible physical and orbital properties of any binary companions: they probably have periods greater than 35 years or masses of brown dwarfs or super-Jupiters. While not ruling out the binary hypothesis, it seems fair to say that these results do not support it.

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Conference Papers

Uncovering the pulsating photospheres of Miras through near-IR interferometry: a case study on R Vir

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The methodology and some preliminary results of our study of the relationship between a Mira's pulsating photosphere

and its surrounding molecular layer(s) throughout several pulsation cycles, based on spatially resolved data, are presented. Our dataset consists of archival narrow-band observations in the near-infrared H and K bands obtained with the Palomar Testbed Interferometer between 1999 and 2006, extended with a few nights of VLTI AMBER low spectral resolution data and near-infrared SAAO photometry. The fitted model is the geometric star + layer model proposed by Perrin et al. (2004), in which the physical parameters (diameter and temperature of star and layer; wavelength dependent optical depth of the layer) are given a sinusoidal time dependence.

Poster contribution, published in "Why galaxies care about AGB stars", Vienna, August 2010, ASP Conference Series
Available from arXiv:1011.5123

Nature of light variations in the symbiotic binary V417 Cen

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V417 Cen is a D′-type symbiotic system surrounded by a faint, extended asymmetric nebula. Optical photometric observations of this object cover last 20 years. They show strong long term modulation with a period of about 1700 days and amplitude about 1.5 mag in V band, in addition to variations with shorter times-scales and much lower amplitudes. In this presentation we discuss possible reasons of these variations.

Poster contribution, published in "Asymmetric Planetary Nebulae 5"
Available from arXiv:1011.5434

From bipolar to elliptical: Morphological changes in the temporal evolution of PNe

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Proto-planetary nebulae (pPN) and planetary nebulae (PN) seem to be formed by interacting winds from asymptotic giant branch (AGB) stars. The observational issue that most pPN are bipolar but most older PN are elliptical is addressed. We present 2.5D hydrodynamical numerical simulations of episodic cooling interacting winds to investigate the long term evolution of PN morphologies. We track wind acceleration, decrease in mass-loss and episodic change in wind geometry from spherical (AGB) to collimated (pPN) and back to spherical again (PN). This outflow sequence is found to produce realistic PN dynamics and morphological histories. Effects from different AGB distributions and jet duty cycles are also investigated.

Oral contribution, published in "Asymmetric Planetary Nebulae V", eds. Zijlstra et al., editorial: Ebrary
Available from arXiv:1011.4312

The many faces of Betelgeuse

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The dynamics of the surface and inner atmosphere of the red supergiant star Betelgeuse are the subject of numerous high angular resolution and spectroscopic studies. Here, we present three-telescope interferometric data obtained at 11.15 μm wavelength with the Berkeley Infrared Spatial Interferometer (ISI), that probe the stellar surface continuum. We find striking variability in the size, effective temperature, and degree of asymmetry of the star over the years 2006–2009. These results may indicate an evolving shell of optically thick material close to the stellar photosphere.

Poster contribution, published in "16$^{\rm th}$ Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun", 29 August – 2 September 2010, Seattle, USA
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The AGB population of NGC 6822

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Themetallicity gradient and the stellar distribution within the Local Group dwarf galaxy NGC 6822 has been studied photometrically using asymptotic branch stars (AGB). In order to study the stellar and metallicity distribution, the carbon- and oxygen-rich AGB stars have been isolated using deep high-quality near-infrared UKIRT photometry. The ratio between them, the C/M ratio, has been used to derive the [Fe/H] abundance within the galaxy. The [Fe/H] abundance and stellar distribution were analysed as a function of galactic radius. A mean C/M ratio of 0.288 ± 0.014 has been found which corresponds to an iron abundance of [Fe/H] $= -1.14 \pm 0.08$ dex, with variations in the North and South, as well as at larger galactocentric distances. Variations in the magnitude of the tip of the red giant branch have also been detected.

Oral contribution, published in "Why Galaxies care about AGB stars II"
Available from arXiv:1011.4464

PACS spectroscopy of OH/IR stars

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Observations of high-excitation molecular emission lines can greatly increase our understanding of AGB winds, as they trace the innermost regions of the circumstellar envelope. The PACS spectrometer on-board the *Herschel* Space Telescope, provides for the first time the spectral resolution and sensitivity necessary to trace these lines. We report on the first modelling efforts of a PACS spectral scan for the OH/IR star V669 Cas. Central to our methodology is the consistent treatment of both dust and gas by using a line radiative transfer and a continuum radiative transfer code conjointly. Water emission lines are found to be extremely sensitive to the dust-to-gas ratio, emphasizing the need of consistent modelling for dust and gas.

Poster contribution, published in "Why Galaxies Care About AGB Stars 2", Vienna 2010
Available from arXiv:1011.4475

Nucleosynthesis and chemical evolution of intermediate-mass stars: results from planetary nebulae

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Planetary nebulae (PN) are an excellent laboratory to investigate the nucleosynthesis and chemical evolution of intermediate mass stars. In these objects accurate abundances can be obtained for several chemical elements that are manufactured or contaminated by the PN progenitor stars, such as He, N, C, and also elements that were originally produced by more massive stars of previous generations, namely O, Ne, Ar, and S. Some of these elements are difficult to study in stars, so that PN can be used in order to complement results obtained from stellar data.
In the past few years, we have obtained a large sample of PN with accurately derived abundances, including objects of different populations, namely the solar neighbourhood, the galactic disk and anticentre, the galactic bulge and the Magellanic Clouds.
In this work, we present the results of our recent analysis of the chemical abundances of He, O, N, S, Ar and Ne in galactic and Magellanic Cloud PN. Average abundances and abundance distributions of all elements are determined, as well as distance-independent correlations. These correlations are particularly important, as they can be directly compared with the predictions of recent theoretical evolutionary models for intermediate mass stars.

Oral contribution, published in "11$^{\text{th}}$ Symposium on Nuclei in the Cosmos", 19–23 July 2010, Heidelberg, Germany
Available from arXiv:1012.0242
and from http://www.astro.iag.usp.br/∼maciel

Integrated properties of AGB stars in unresolved stellar populations : Single stellar populations and star clusters

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The evolution of AGB stars is notoriously complex. The confrontation of AGB population models with observed stellar populations is a useful alternative to the detailed study of individual stars in efforts to converge towards a reliable evolution theory. I review here the impact of studies of star clusters on AGB models and AGB population synthesis, deliberately leaving out any more complex stellar populations. Over the last 10 years, despite much effort, the absolute uncertainties in the predictions of the light emitted by intermediate age populations have not been reduced to a satisfactory level. Observational sample definitions, as well as the combination of the natural variance in AGB properties with small number statistics, are largely responsible for this situation. There is hope that the constraints may soon become strong enough, thanks to large unbiased surveys of star clusters, resolved colour–magnitude diagrams, and new analysis methods that can account for the stochastic nature of AGB populations in clusters.

Oral contribution, published in "Why Galaxies Care about AGB Stars II"
Available from arXiv:1011.4821

Direct imaging with a hypertelescope of red supergiant stellar surfaces

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High angular resolution images obtained with a hypertelescope can strongly constrain the radiative-hydrodynamics

simulations of red supergiant (RSG) stars, in terms of intensity contrast, granulation size and temporal variations of the convective motions that are visible on their surface. The characterization of the convective pattern in RSGs is crucial to solve the mass-loss mechanism which contributes heavily to the chemical enrichment of the Galaxy. We show here how the astrophysical objectives and the array configuration are highly dependent to design a hypertelescope. For a given field of view and a given resolution, there is a trade-off between the array geometry and the number of required telescopes to optimize either the (u, v) coverage (to recover the intensity distribution) or the dynamic range (to recover the intensity contrast). To obtain direct snapshot images of Betelgeuse with a hypertelescope, a regular and uniform layout of telescopes is the best array configuration to recover the intensity contrast and the distribution of both large and small granulation cells, but it requires a huge number of telescopes (several hundreds or thousands). An annular configuration allows a reasonable number of telescopes (lower than one hundred) to recover the spatial structures but it provides a low-contrast image. Concerning the design of a pupil densifier to combine all the beams, the photometric fluctuations are not critical (Δ photometry $< 50\%$) contrary to the residual piston requirements ($OPD < \lambda/8$) which requires the development of an efficient cophasing system to fully exploit the imaging capability of a hypertelecope.

Oral contribution, published in "Optical and Infrared Interferometry II", Eds. W.C. Danchi, F. Delplancke & J.K. Rajagopal, SPIE, Volume 7734, p. 77341G (2010)
Available from http://spiedl.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=
PSISDG00773400000177341G000001&idtype=cvips&gifs=yes&ref=no

Accretion and diffusion in the DAZ white dwarf GALEX J1931+0117

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We present an analysis of high-dispersion and high signal-to-noise ratio spectra of the DAZ white dwarf GALEX J1931 +0117. The spectra obtained with the VLT-Kueyen/UV-Visual Echelle Spectrograph show several well-resolved Si II spectral lines enabling a study of pressure effects on line profiles. We observed large Stark shifts in silicon lines in agreement with laboratory measurements. A model atmosphere analysis shows that the magnesium, silicon and iron abundances exceed solar abundances, while the oxygen and calcium abundances are below solar. Also, we compared the observed line profiles to synthetic spectra computed with variable accretion rates and vertical abundance distributions assuming diffusion steady-state. The inferred accretion rates vary from $\dot{M} = 2 \times 10^6$ for calcium to 2×10^9 g s^{-1} for oxygen and indicate that the accretion flow is dominated by oxygen, silicon and iron while being deficient in carbon, magnesium and calcium. The lack of radial velocity variations between two measurement epochs suggests that GALEX J1931+0117 is probably not in a close binary and that the source of the accreted material resides in a debris disc.

Oral contribution, published in "Planetary Systems beyond the Main Sequence"
Available from arXiv:1012.2644

Interpretation of the line spectrum of classical symbiotic stars in the scenario for their prototype Z And

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Results of the study of the symbiotic binary Z And during its recent active phase 2000–2010 when it experienced a series of six optical outbursts are presented. High-resolution spectra obtained during the first and fourth outburst, which was the strongest one, have been analyzed. These data are compared with results of theoretical computations. The comparison provides information about the behaviour of the system during the entire active phase rather than during

an individual outburst. In particular it was found fundamental difference between the first outburst which opened the active phase and the recurrent outbursts – namely, the presence of bipolar collimated optical outflow during some of the recurrent outbursts. A scenario that can explain all the spectroscopic phenomena observed during this active phase as well as previous active phases of Z And is proposed. The possibility to use this scenario for explanation of the line spectrum of other classical symbiotic stars during their active phases is motivated.

Oral contribution, published in School and Workshop on "Space Plasma Physics", held in Kiten, Bulgaria, September 1–12 2010; AIP Conf. Proceedings
Available from arXiv:1012.2803

Review Paper

News from low-mass star nucleosynthesis and mixing

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Light and intermediate nuclei as well as s-process elements have been detected in presolar grains and in evolved red giants. The abundances of some of these nuclei cannot be accounted for by canonical stellar models and require non-convective mixing below the envelope, occurring during the phases of the Red Giant Branch (RGB) and of the Asymptotic Giant Branch (AGB). Similar mechanisms appear to be necessary to account for the formation of the neutron source driving s-processing. We present a short review of these phenomena and we comment on the picture that emerges from the set of available data on the evolution and nucleosynthesis in low mass stars. Our conclusions include: i) the need for deep mixing in both RGB and AGB stars; ii) the suggestion that these phenomena occur at a non-negligible velocity, possibly incompatible with diffusive processes; iii) the verification that the abundances of neutron-rich nuclei are presently increasing in the galaxy, contrary to previous expectations and hence that the s process has new surprises to offer us; iv) the recognition of the growing importance of very low mass stars for galactic nucleosynthesis.

Published in "Giants 2010 Meeting", LNGS Publication
Available from arXiv:1012.2546

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Enquiries: Professor Quentin Parker, phone +61 2 9850 8910, e-mail quentin.parker@mq.edu.au

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See also http://www.physics.mq.edu.au/astronomy/jobs/index.html

Announcement

Proceedings: Planetary Systems Beyond the Main Sequence 2010

We are glad to announce the upcoming publication of the Conference Proceedings of "Planetary Systems Beyond the Main Sequence", held 11–14 August 2010 in Bamberg, Germany, as AIP Conference Proceedings, Volume 1331, American Institute of Physics, New York (in press).

This conference was the first to discuss the fate of a planet and its host star when the star evolves into a red giant and finally ends its life as a white dwarf. Scientists specialised in stellar evolution met experts from the exoplanet field to discuss this interplay.

The Author Versions of all those contributions which have been submitted to the arXiv Preprint Server may be accessed via the Table of Contents at the arXiv Index Website below.

S. Schuh, U. Heber, H. Drechsel (eds.)

See also http://arxiv.org/abs/1011.6606