# THE AGB NEWSLETTER

*An electronic publication dedicated to Asymptotic Giant Branch stars and related phenomena*

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Editors: Jacco van Loon and Albert Zijlstra

## *Editorial*

Dear Colleagues,

It is our pleasure to present the 114$^{\rm th}$ issue of the AGB Newsletter. The submissions are (again) heavily dominated by studies of post-AGB stars, Planetary Nebulae (PNe) or white dwarfs, including two review articles. These objects are interesting in their own right but also because many of their properties depend on the properties and evolution of their progenitor, which in most cases is believed to be an AGB star.

Three very interesting articles present studies of AGB stars and red supergiants in the galactic globular cluster 47 Tucanae (Beccari et al.), the Local Group dwarf elliptical galaxy M 32 (Davidge & Jensen) and the nearby spiral galaxy M 81 (Davidge), clearly demonstrating the power of population studies to learn about the stars as well as the stellar systems they inhabit. Likewise, a new survey for PNe in the LMC reveals intriguing spatial and kinematical structure of this irregular galaxy (Reid & Parker), whilst a study of the central stars of a subset of these PNe suggests slightly higher masses than in the Milky Way with interesting possible implications for their progenitors (Villaver et al.) — on the other hand, Williams finds no metallicity dependence of the initial-final mass relation in galactic clusters.

It is also encouraging to see good general agreement between current model atmospheres and new interferometric data of red giant stars of $T_{\rm eff} \sim 3800$ K (please see the two papers by Wittkowski et al.). We can eagerly await the next generation of VLTI instruments, and more results on cooler giants.

If you are looking for a job, please consider the advertisements for tenure-track positions at the universities of Monash (Australia) and Denver (USA), that have an interest in hiring from among the AGB star community.

The next issue will be distributed on the 1$^{\rm st}$ of December; the deadline for contributions is the 30$^{\rm th}$ of November.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

## *Food for Thought*

This month's thought-provoking statement is:

*It is surprising that the initial-final mass relation of white dwarfs depends so little on metallicity*

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*

## Spectroscopic survey of post-AGB star candidates

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Aims : Establish the true nature of post-AGB star candidates in order to identify new post-AGB stars.
Methods : Low resolution optical spectroscopy; comparison of the spectra of the candidate post-AGB stars with those of stars in the library specta available in the literature and with spectra of "standard" post-AGB stars; direct imaging in narrow-band filters.
Results : Spectra have been obtained for 16 objects: 14 objects have not been previously observed and 2 objects are already known post-AGB stars used as "standards" for identification. From the spectra we identify: six new post-AGB stars with spectral types between G5 and F5; two H II regions the morphology of which is revealed in the direct images for the first time; a G giant with infrared emission; a young stellar object; a probable post-AGB star with emission lines; and three objects for which the classification is still unclear. As a whole, our results provide new, reliable identifications for 10 objects among listed post-AGB star candidates.

**Accepted for publication in Astronomy & Astrophysics**

## Detection of $HCO^+$ Emission toward the Planetary Nebula K 3-35

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We report the detection, for the first time, of $HCO^+$ ($J = 1 \rightarrow 0$) emission as well as marginal CO ($J = 1 \rightarrow 0$) emission toward the planetary nebula (PN) K 3-35 as a result of a molecular survey carried out toward this source. We also report new observations of the previously detected CO ($J = 2 \rightarrow 1$) and water maser emission, as well as upper limits for the emission of the SiO, $H^{13}CO^+$, HNC, HCN, $HC_3OH$, $HC_5N$, CS, $HC_3N$, $^{13}CO$, CN, and $NH_3$ molecules. From the ratio of CO ($J = 2 \rightarrow 1$) to CO ($J = 1 \rightarrow 0$) emission we have estimated the kinetic temperature of the molecular gas, obtaining a value of $\simeq$ 20 K. Using this result, we have estimated a molecular mass for the envelope of $\simeq 0.017\ M_\odot$, and an $HCO^+$ abundance relative to $H_2$ of $6 \times 10^{-7}$, similar to the abundances found in other PNe. K 3-35 is remarkable because it is one of the two PNe reported to exhibit water maser emission, which is present in the central region as well as at a distance of $\simeq$ 5000 AU away from the center. The presence of molecular emission provides some clues that could help to understand the persistence of water molecules in the envelope of K 3-35. The $HCO^+$ emission could be arising in dense molecular clumps, that may provide the shielding mechanism which protects water molecules in this source.

**Accepted for publication in Astronomical Journal**
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# Near-infrared polarimetry and modelling of the dusty young PN IRAS 19306+1407

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We present near-infrared polarimetric images of the dusty circumstellar envelope (CSE) of IRAS 19306+1407, acquired at the United Kingdom Infrared Telescope (UKIRT) using the UKIRT 1-5 $\mu$m Imager Spectrometer (UIST) in conjunction with the half-waveplate module IRPOL2. We present additional 450 and 850 $\mu$m photometry obtained with the Sub-mm Common User Bolometer Array (SCUBA) at the James Clerk Maxwell Telescope (JCMT), as well as archived Hubble Space Telescope (HST) F606W- and F814W-filter images. The CSE structure in polarized flux at J- and K-bands shows an elongation NNE-SSW with two bright scattering shoulders NW-SE. These features are not perpendicular to each other and could signify a recent 'twist' in the outflow axis. We model the CSE using an axisymmetric light scattering (ALS) code to investigate the polarization produced by the CSE, and an axisymmetric radiation transport (DART) code to fit the SED. A good fit was achieved with the ALS and DART models using silicate grains, 0.1-0.4 $\mu$m with a power-law size distribution of $a^{-3.5}$, and an axisymmetric shell geometry with an equator-to-pole contrast of 7:1. The spectral type of the central star is determined to be B1I supporting previous suggestions that the object is an early PN. We have constrained the CSE and interstellar extinction as 2.0 and 4.2 mag respectively, and have estimated a distance of 2.7 kpc. At this distance the stellar luminosity is $\sim$4500 $L_\odot$ and the $\sim$5300 yrs with a mass-loss rate of $\sim 3.4 \times 10^{-5}$ $M_\odot$ yr$^{-1}$.

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*and from* http://star-www.herts.ac.uk/$\sim$klowe/

# Isolated versus Common Envelope Dynamos in Planetary Nebula Progenitors

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The origin, evolution and role of magnetic fields in the production and shaping of proto-planetary and planetary nebulae (PPNe, PNe) is a subject of active research. Most PNe and PPNe are axisymmetric with many exhibiting highly collimated outflows, however, it is important to understand whether such structures can be generated by isolated stars or require the presence of a binary companion. Toward this end we study a dynamical, large-scale $\alpha - \Omega$ interface dynamo operating in a 3.0 $M_\odot$ Asymptotic Giant Branch star (AGB) in both an isolated setting and one in which a low-mass companion is embedded inside the envelope. The back reaction of the fields on the shear is included and differential rotation and rotation deplete via turbulent dissipation and Poynting flux. For the isolated star, the shear must be resupplied in order to sufficiently sustain the dynamo. Furthermore, we investigate the energy requirements that convection must satisfy to accomplish this by analogy to the sun. For the common envelope case, a robust dynamo results, unbinding the envelope under a range of conditions. Two qualitatively different types of explosion may arise: (i) magnetically induced, possibly resulting in collimated bipolar outflows and (ii) thermally induced from turbulent dissipation, possibly resulting in quasi-spherical outflows. A range of models is presented for a variety of companion masses.

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# AGB nucleosynthesis in the Large Magellanic Cloud. Detailed abundance analysis of the RV Tauri star MACHO47.2496.8.

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Context. Abundance analysis of post-AGB objects as probes of AGB nucleosynthesis. Aims. A detailed photospheric abundance study is performed on the carbon-rich post-AGB candidate MACHO 47.2496.8 in the LMC. Methods. High-resolution, high signal-to-noise ESO VLT-UVES spectra of MACHO 47.2496.8 are analysed by performing detailed spectrum synthesis modelling using state-of-the-art carbon-rich MARCS atmosphere models. Results. The spectrum of MACHO 47.2496.8 is not only dominated by bands of carbon bearing molecules, but also by lines of atomic transitions of s-process elements. The metallicity of $[\mathrm{Fe/H}] = -1.4$ is surprisingly low for a field LMC star. The C/O ratio, however difficult to quantify, is greater than 2, and the s-process enrichment is large: the light s-process elements are enhanced by 1.2 dex compared to iron ($[\mathrm{ls/Fe}] = +1.2$), while for the heavy s-process elements an even stronger enrichment is measured: $[\mathrm{hs/Fe}] = +2.1$. The lead abundance is comparable to the [hs/Fe]. With its low intrinsic metallicity and its luminosity at the low end of the carbon star luminosity function, the star represents likely the final stage of a low initial mass star. Conclusions. The LMC RV Tauri star MACHO 47.2496.8 is highly carbon and s-process enriched, and is most probable a genuine post-C(N-type) AGB star. This is the first detailed abundance analysis of an extragalactic post-AGB star to date.

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# The Mass Distribution of the Central Stars of Planetary Nebulae in the Large Magellanic Cloud

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We present the properties of the central stars from a sample of 54 Planetary Nebulae (PNe) observed in the Large Magellanic Cloud (LMC) with the Hubble Space Telescope Imaging Spectrograph (STIS). The Hubble Space Telescope's spatial resolution allows us to resolve the central star from its nebula (and line-of-sight stars) at the distance of the LMC, eliminating the dependency on photoionization modeling in the determination of the stellar flux. For the PNe in which the central star is detected we obtain the stellar luminosities by directly measuring the stellar fluxes through broad-band imaging and the stellar temperatures through Zanstra analysis. From the position of the central stars in the HR diagram with respect to theoretical evolutionary tracks, we are able to determine reliable core masses for 21 central stars. By including the central star masses determined in this paper to the 16 obtained previously using the same technique (Villaver et al. 2003), we have increased the sample of central star masses in the LMC to 37, for which we find a non-Gaussian mass distribution. The average central star mass for this sample is $\langle m_{\mathrm{CS,LMC}} \rangle = 0.65 \pm 0.07$ $\mathrm{M}_{\odot}$, slightly higher than the one reported in the literature for both white dwarfs and the central stars of PNe in the Galaxy. If significant, this higher average central star mass in the LMC can be understood in terms of a metallicity dependency on mass-loss rates during the Asymptotic Giant Branch, since the LMC has on average half the metallicity compared to the Galaxy. Finally, for the 37 objects analyzed in the LMC, we do not find any significant correlation between the mass of the central star and the morphology of the nebula.

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# Tests of stellar model atmospheres by optical interferometry III: NPOI and VINCI interferometry of the M0 giant gamma Sge covering 0.5 - 2.2 microns

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Aims: We present a comparison of the visual and NIR intensity profile of the M0 giant gamma Sagittae to plane-parallel ATLAS 9 as well as to plane-parallel & spherical PHOENIX model atmospheres. Methods: We use previously described visual interferometric data obtained with the NPOI in July 2000. We apply the recently developed technique of coherent integration, and thereby obtain visibility data of more spectral channels and with higher precision than before. In addition, we employ new measurements of the K-band diameter of gamma Sagittae obtained with the instrument VINCI at the VLTI in 2002. Results: The spherical PHOENIX model leads to a precise definition of the Rosseland angular diameter and a consistent high-precision diameter value for our NPOI and VLTI/VINCI data sets of $\Theta_{\rm Ross} = 6.06 \pm 0.02$ mas, with the Hipparcos parallax corresponding to $R_{\rm Ross} = 55 \pm 4$ R$_\odot$, and with the bolometric flux corresponding to an effective temperature $T_{\rm eff} = 3805 \pm 55$ K. Our visual visibility data close to the first minimum and in the second lobe constrain the limb-darkening effect and are generally consistent with the model atmosphere predictions. The visual closure phases exhibit a smooth transition between 0 and $\pi$. Conclusions: The agreement between the NPOI and VINCI diameter values increases the confidence in the model atmosphere predictions from optical to NIR wavelengths as well as in the calibration and accuracy of both interferometric facilities. The consistent night-by-night diameter values of VINCI give additional confidence in the given uncertainties. The closure phases suggest a slight deviation from circular symmetry, which may be due to surface features, an asymmetric extended layer, or a faint unknown companion.

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# Tests of stellar model atmospheres by optical interferometry IV: VINCI interferometry and UVES spectroscopy of Menkar

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We present K-band interferometric and optical spectroscopic observations of Menkar obtained with the instruments VINCI and UVES at Paranal Observatory. Spherically symmetric PHOENIX stellar model atmospheres are constrained by comparison to our interferometric and spectroscopic data, and high-precision fundamental parameters of Menkar are obtained. Our high-precision VLTI/VINCI observations in the first and second lobes of the visibility function directly probe the model-predicted strength of the limb darkening effect in the K-band and the stellar angular diameter. The high spectral resolution of UVES allows us to confront observed and model-predicted profiles of atomic lines and molecular bands. We show that our derived PHOENIX model atmosphere for Menkar is consistent with both the measured strength of the limb-darkening in the near-infrared K-band and the profiles of spectral bands around selected atomic lines and TiO bandheads. At the detailed level of our high spectral resolution, however, noticeable discrepancies between observed and synthetic spectra exist. We obtain a Rosseland angular diameter of $\Theta_{\rm Ross} = 12.20 \pm 0.04$ mas. Together with the Hipparcos parallax, it corresponds to $R_{\rm Ross} = 89 \pm 5$ R$_\odot$, and together with the bolometric flux to $T_{\rm eff} = 3795 \pm 70$ K.Our approach illustrates the power of combining interferometry and

high-resolution spectroscopy to constrain and calibrate stellar model atmospheres. The simultaneous agreement of the model atmosphere with our interferometric and spectroscopic data increases confidence in the reliability of the modelling of this star, while discrepancies at the detailed level of the high resolution spectra can be used to further improve the underlying model.

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## A population of binaries in the Asymptotic Giant Branch of 47 Tucanae?

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We have used a set of archived Hubble Space Telescope/ACS images to probe the evolved populations of the globular cluster 47 Tucanae. We find an excess of Asymptotic Giant Branch (AGB) stars in the cluster core. We interpret this feature as the signature of an extra-population likely made by the progeny of massive stars originated by the evolution of binary systems. Indeed the comparison with theoretical tracks suggests that the AGB population of 47 Tuc can be significantly contaminated by more massive stars currently experiencing the first ascending Red Giant Branch.

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## A 1.2 mm MAMBO survey of Post-AGB stars

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We performed a millimetric survey of a sample of 24 post-AGB stars aimed to search for emission from circumstellar matter, in order to investigate the physical properties of the outer parts of the envelopes.
The observations were conducted using the 37-channel Max-Planck Millimeter Bolometer array at the 30-meter IRAM telescope. The continuum emission toward the detected sources was used to quantify the mass of the emitting dust. We combined our observations with data available in literature to construct the spectral energy distribution (SED) of the sources. When the observational data cover a spectral range wide enough, some properties of circumstellar envelopes were derived by comparison with spectra computed using a radiative transfer code.
Of the 24 objects in our sample, we detected millimetric continuum emission toward 11 sources. Two other sources were detected at flux level close to $3\sigma$. The derived circumstellar dust masses range between 0.4 and $24 \times 10^{-4}$ $M_{\odot}$, but these results are affected from the uncertain about the source distances. The parameters derived from the SED fits are consistent with the values characteristic for these kind of object. As confirmed from the flux density extrapolated in the first light channels of the Atacama Large Millimetric Array, such sources would be good targets for future high resolution mapping with the ALMA facility.

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## On the asymptotic giant branch star origin of peculiar spinel grain OC2

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The composition of presolar spinel grain OC2 is different from that of all other presolar spinel grains. In particular, large excesses of the heavy Mg isotopes are present and thus an origin from an intermediate-mass (IM) asymptotic giant branch (AGB) star was previously proposed for this grain. We discuss the O, Mg, Al, Cr and Fe isotopic compositions of presolar spinel grain OC2 and compare them to theoretical predictions. We use detailed models of the evolution and nucleosynthesis of AGB stars of different masses and metallicities to compare to the composition of grain OC2. We analyse the uncertainties related to nuclear reaction rates and also discuss stellar model uncertainties. We show that the isotopic composition of O, Mg and Al in OC2 could be the signature of an AGB star of IM and metallicity close to solar experiencing hot bottom burning, or of an AGB star of low mass (LM) and low metallicity ($\simeq$0.004) suffering very efficient cool bottom processing. Large measurement uncertainty in the Fe isotopic composition prevents us from discriminating which model better represents the parent star of OC2. However, the Cr isotopic composition of the grain favors an origin in an IM-AGB star of metallicity close to solar. Our IM-AGB models produce a self-consistent solution to match the composition of OC2 within the uncertainties related to reaction rates. Within this solution we predict that the $^{16}O(p,\gamma)^{17}F$ and the $^{17}O(p,\alpha)^{14}N$ reaction rates should be close to their lower and upper limits, respectively. By finding more grains like OC2 and by precisely measuring their Fe and Cr isotopic compositions, it may be possible in the future to derive constraints on massive AGB models from the study of presolar grains.

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## New nonadiabatic pulsation computations on full PG1159 evolutionary models: the theoretical GW Vir instability strip revisited

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We reexamine the theoretical instability domain of pulsating PG1159 stars (GW Vir variables). We performed an extensive $g$-mode stability analysis on PG1159 evolutionary models with stellar masses ranging from 0.530 to 0.741 $M_\odot$, for which the complete evolutionary stages of their progenitors from the ZAMS, through the thermally pulsing AGB and born-again phases to the domain of the PG1159 stars have been considered. We found that pulsations in PG1159 stars are excited by the $\kappa$-mechanism due to partial ionization of carbon and oxygen, and that no composition gradients are needed between the surface layers and the driving region, much in agreement with previous studies. We show, for the first time, the existence of a red edge of the instability strip at high luminosities. We found that all of the GW Vir stars lay within our theoretical instability strip. Our results suggest a qualitative good agreement between the observed and the predicted ranges of unstable periods of individual stars. Finally, we found that generally the seismic masses (derived from the period spacing) of GW Vir stars are somewhat different from the masses suggested by evolutionary tracks coupled with spectroscopy. Improvements in the evolution during the thermally pulsing AGB phase and/or during the core helium burning stage and early AGB could help to alleviate the persisting discrepancies.

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# Asteroseismic inferences on GW Vir variable stars in the frame of new PG 1159 evolutionary models

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An adiabatic, nonradial pulsation study of GW Vir stars is presented. The pulsation calculations are based on PG1159 evolutionary sequences with different stellar massess artificially derived from a full evolutionary sequence of 0.5895 $M_\odot$ that has been computed taking into account the evolutionary history of the progenitor star. The artificial sequences were constructed by appropriately scaling the stellar mass of the 0.5895 $M_\odot$ sequence well before the models reach the low-luminosity, high-gravity stage of the GW Vir domain. We compute $g$-mode pulsation periods appropriate to GW Vir variable stars. The implications for the mode-trapping properties of our PG 1159 models are discussed at length. We found that the mode-trapping features characterizing our PG 1159 models are mostly fixed by the stepped shape of the core chemical profile left by prior convective overshooting. This is particularly true at least for the range of periods observed in GW Vir stars. In addition, we make asteroseismic inferences about the internal structure of the GW Vir stars PG 1159-035, PG 2131+066, PG 1707+427 and PG 0122+200.

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# Asteroseismological constraints on the pulsating planetary nebula nucleus (PG1159-type) RX J2117.1+3412

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We present asteroseismological inferences on RX J2117.1+3412, the hottest known pulsating PG1159 star. Our results are based on full PG1159 evolutionary models recently presented by Miller Bertolami & Althaus (2006). We performed extensive computations of adiabatic $g$-mode pulsation periods on PG1159 evolutionary models with stellar masses ranging from 0.530 to 0.741 $M_\odot$. PG1159 stellar models are extracted from the complete evolution of progenitor stars started from the ZAMS, through the thermally pulsing AGB and born-again phases to the domain of the PG1159 stars. We constrained the stellar mass of RX J2117.1+3412 by comparing the observed period spacing with the asymptotic period spacing and with the average of the computed period spacings. We also employed the individual observed periods to find a representative seismological model for RX J2117.1+3412. We derive a stellar mass $M_\star$ ∼0.56-0.57 $M_\odot$ from the period spacing data alone. In addition, we found a best-fit model representative for RX J2117.1+3412 with an effective temperature $T_{\rm eff} = 163\,400$ K, a stellar mass $M_\star = 0.565\ M_\odot$, and a surface gravity $\log g = 6.61$. The derived stellar luminosity and radius are $\log(L_\star/L_\odot) = 3.36$ and $\log(R_\star/R_\odot) = -1.23$, respectively, and the He-rich envelope thickness is $M_{\rm env} = 0.02\ M_\odot$. We derive a seismic distance $d \sim 452$ pc and a linear size of the planetary nebula $D_{\rm PN} \sim 1.72$ pc. These inferences seem to solve the discrepancy between the RX J2117.1+3412 evolutionary timescale and the size of the nebula. All of the seismological tools we use concur to the conclusion that RX J2117.1+3412 must have a stellar mass $M_\star \sim 0.565\ M_\odot$, much in agreement with recent asteroseismology studies and in clear conflict with the predictions of spectroscopy plus evolutionary tracks.

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# A New Population of Planetary Nebulae Discovered in the Large Magellanic Cloud (II): Complete PN Catalogue

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This paper presents accurate homogeneous positions, velocities and other pertinent properties for 460 newly discovered and 169 previously known planetary nebulae (PNe) in the central 25 sq deg bar region of the Large Magellanic Cloud (LMC). Candidate emission sources were discovered using a deep, high resolution H$\alpha$ map of the LMC obtained by median stacking a dozen 2 hour H$\alpha$ exposures taken with the UK Schmidt Telescope (UKST). Our spectroscopic followup of more than 2,000 compact (ie. $< 20''$) H$\alpha$ emission candidates uncovered has tripled the number of PNe in this area. All of the 169 previously known PNe within this region have also been independently recovered and included in this paper to create a homogeneous data set. Of the newly discovered PNe, we classify 291 as "true", 54 as "likely" and 115 as "possible" based on the strength of photometric and spectroscopic evidence. Radial velocities have been measured using both weighted averaging of emission lines and cross-correlation techniques against high quality templates. Based on the median comparison of the two systems, we define a measurement error of $\pm 4$ km/s. A new velocity map of the central 25 sq deg of the LMC, based on results from the combined new and previously known PNe, is presented, indicating an averaged heliocentric velocity differential of 65 km/s perpendicular to the line of nodes for the entire PN population across our survey area. Averaged velocities of our PNe and molecular hydrogen (from the literature) across $37' \times 37'$ sub areas are compared. The PNe are found to have a higher vertical velocity dispersion than the H I disk to a maximum of 10 times the spread of the H I disk, in keeping with the findings of Meatheringham et al. (1988). In addition, moving out from the main bar, we find that the PNe population follows a plane which is somewhat warped in relation to the H I disk. We estimate the total PN population of the entire LMC system, based on our R-equiv H$\alpha$ limiting magnitude of $\sim$22, to be $956 \pm 141$.

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# X-Ray Emission from Planetary Nebulae Calculated by 1D Spherical Numerical Simulations

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We calculate the X-ray emission from both constant and time evolving shocked fast winds blown by the central stars of planetary nebulae (PNs) and compare with observations. Using spherically symmetric numerical simulations with radiative cooling, we calculate the flow structure, and the X-ray temperature and luminosity of the hot bubble formed by the shocked fast wind. We find that a constant fast wind gives results that are very close to those obtained from the self-similar solution. We show that in order for a fast shocked wind to explain the observed X-ray properties of PNs, rapid evolution of the wind is essential. More specifically, the mass loss rate of the fast wind should be high early on when the speed is $\sim$300-700 km/s, and then it needs to drop drastically by the time the PN age reaches $\sim$1000 yr. This implies that the central star has a very short pre-PN (post-AGB) phase.

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# Technetium and the third dredge up in AGB stars II. Bulge stars

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We searched for Technetium (Tc) in a sample of bright oxygen-rich asymptotic giant branch (AGB) stars located in the outer galactic bulge. Tc is an unstable element synthesised via the s-process in deep layers of AGB stars, thus it is a reliable indicator of both recent s-process activity and third dredge-up. We aim to test theoretical predictions on the luminosity limit for the onset of third dredge-up. Using high resolution optical spectra obtained with the UVES spectrograph at ESO's VLT we search for resonance lines of neutral Tc in the blue spectral region of our sample stars. These measurements allow us to improve the procedure of classification of stars with respect to their Tc content by using flux ratios. Synthetic spectra based on MARCS atmospheric models are presented and compared to the observed spectra around three lines of Tc. Bolometric magnitudes are calculated based on near infrared photometry of the objects. Among the sample of 27 long period bulge variables four were found to definitely contain Tc in their atmospheres. The luminosity of the Tc rich stars is in agreement with predictions from AGB evolutionary models on the minimum luminosity at the time when third dredge-up sets in. However, AGB evolutionary models and a bulge consisting of a single old population cannot be brought into agreement. This probably means that a younger population is present in the bulge, as suggested by various authors, which contains the Tc-rich stars here identified.

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# High-resolution ultraviolet spectroscopy of PG1159−035 with HST and FUSE

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PG1159−035 is the prototype of the PG1159 spectral class which consists of extremely hot hydrogen-deficient (pre-) white dwarfs. It is also the prototype of the GW Vir variables, which are non-radial g-mode pulsators. The study of PG1159 stars reveals insight into stellar evolution and nucleosynthesis during AGB and post-AGB phases. We perform a quantitative spectral analysis of PG1159−035 focusing on the abundance determination of trace elements. We have taken high-resolution ultraviolet spectra of PG1159−035 with the Hubble Space Telescope and the Far Ultraviolet Spectroscopic Explorer. They are analysed with non-LTE line blanketed model atmospheres. We confirm the high effective temperature with high precision ($T_{\rm eff}$=140 000±5000 K) and the surface gravity of $\log g = 7$. For the first time we assess the abundances of silicon, phosphorus, sulfur,and iron. Silicon is about solar. For phosphorus we find an upper limit of solar abundance. A surprisingly strong depletion of sulfur (2% solar) is discovered. Iron is not detected, suggesting an upper limit of 30% solar. This coincides with the Fe deficiency found in other PG1159 stars. We redetermine the nitrogen abundance and find it to be lower by one dex compared to previous analyses. The sulfur depletion is in contradiction with current models of AGB star intershell nucleosynthesis. The iron deficiency confirms similar results for other PG1159 stars and is explained by the conversion of iron into heavier elements by n-capture in the s-processing environment of the precursor AGB star. However, the extent of the iron depletion is stronger than predicted by evolutionary models. The relatively low nitrogen abundance compared to other pulsating PG1159 stars weakens the role of nitrogen as a distinctive feature of pulsators and non-pulsators in the GW Vir instability strip.

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## Intrinsic properties of the magnetically collimated water maser jet of W43A

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Water maser polarization observations in the precessing jet of W43A have revealed that it is magnetically collimated. Here we present a detailed description of the physical properties of the water maser environment in the jet. We discuss the maser saturation level and beaming angle as well as the intrinsic temperatures and densities. Additionally, we show that the polarization angle of the strongest red-shifted maser feature undergoes a fast rotation of 90 degrees across the maser. Along with the variation of linear polarization fraction, this strongly supports the current theoretical description of maser linear polarization.

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*Available from* astro-ph/0607337

## Comparing $\eta$ Carinae with the Red Rectangle

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I compare the structures of the bipolar nebulae around the massive binary system $\eta$ Carinae and around the low mass binary system HD 44179. While $\eta$ Carinae is on its way to become a supernova, the Red Rectangle is on its way to form a planetary nebula. Despite the two orders of magnitude difference in mass, these two systems show several similarities, both in the properties of the stellar binary systems and the nebulae. From this comparison and further analysis of the accretion process during the 20 years Great Eruption of $\eta$ Carinae, I strengthen the binary model for the formation of its bipolar nebula–the Homunculus. In the binary model a large fraction of the mass lost by the primary star during the Great Eruption was transferred to the secondary star (the companion); An accretion disk was formed around the companion, and the companion launched two opposite jets. I show that the gravitational energy of the mass accreted onto the secondary star during the Great Eruption can account for the extra energy of the Great Eruption, both the radiated energy and the kinetic energy in the Homunculus. I also conclude that neither the proximity of the primary star in $\eta$ Car to the Eddington luminosity, nor the rotation of the primary star are related directly to the shaping of the Homunculus. I speculate that the Great Eruption of $\eta$ Carinae was triggered by disturbance in the outer boundary of the convective region, most likely by magnetic activity, that expelled the outer radiative zone.

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## IC 5217 as a double-shell, point-symmetric planetary nebula with a very narrow waist

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Aims: Identification of the structural components and analysis of the internal kinematics in the planetary nebula IC 5217. Methods: Narrow-band images and high resolution long-slit spectra in the H$\alpha$, [N II] and [O III] emission lines, and VLA 6 cm continuum data. Results: IC 5217 is composed of a very bright equatorial ring, open bipolar lobes, off-axis point-symmetric features, on-axis distant faint regions, and an off-axis very elongated bipolar structure. The ring, open lobes,point-symmetric features and distant faint regions appear as elements of a single point-symmetric

bipolar shell with a very narrow waist. This shell presents an axis ratio of ∼37 and an aspect ratio of ∼5. The 6 cm data show that the ring is an extremely flat disk with a central hole. Expansion velocity in the ring ranges from ≤10 km s$^{-1}$ in He II up to ≃27 km s$^{-1}$ in [N II], whereas a velocity of ∼460 km s$^{-1}$ is estimated for the polar regions of the bipolar shell. Strong acceleration of the outer regions of the ring is observed. The elongated bipolar structure probably represents a highly collimated (aspect ratio ∼12), high velocity cylindrical-like shell. A collimated agent (wind or jet) would account for the shaping of the bipolar shell if this agent has operated in the direction perpendicular to the equatorial disk. The point-symmetric features and cylindrical shell are probably related to collimated ejections but that occurred when the basic nebular shape had already been established.

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## The Brightest Stars in M32: Comparing Predictions from Spectra with the Resolved Stellar Content

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Broad- and narrow-band images covering the $1 - 4\mu$m wavelength interval are used to investigate the properties of the brightest AGB stars in the Local Group galaxy M32. Data obtained with the NIRI imager on the Gemini North Telescope indicate that the brightest AGB stars near the center of M32 have peak $M_{L'}$ brightnesses and $K - L'$ colors that are similar to those of luminous AGB stars in the Galactic disk. Data obtained with the CFHTIR imager on the Canada-France-Hawaii Telescope indicate that the density of bright AGB stars per unit visible and near-infrared surface brightness is constant out to projected major axis distances of 1 kpc, suggesting that the AGB stars and their progenitors are smoothly mixed. In addition, the $J - K$ color distribution of bright AGB stars throughout much of the galaxy is consistent with that of a single population of AGB stars, the majority of which are long period variables, having a common metallicity and age. The photometric properties of the brightest AGB stars do not change in regions where the isophotal properties of the galaxy change. Thus, these data do not support spectroscopic studies that find an age gradient in M32. The AGB contributes $70^{+30\%}_{-20\%}$ of the integrated light in the region surveyed. This is consistent with previous estimates made from the integrated near-infrared spectrum, and is suggestive of an age ∼ 2 Gyr. The stellar content of M32 is compared with that of the M31 bulge at a projected minor axis distance of 1.4 kpc. While the peak $K-$band brightnesses of AGB stars in the two systems agree to within a few tenths of a magnitude, M32 contains more bright AGB stars per unit integrated brightness than the outer bulge of M31. This is suggestive of a difference in mean age, and it is concluded that the star forming histories of M32 and the bulge of M31 have differed over a significant fraction of their lifetimes, which is consistent with spectroscopic studies of these systems. The well-mixed AGB content of M32 is consistent with the galaxy having been tidally stirred, presumably by interactions with M31.

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*Available from* astro-ph/0610644

## Red Supergiants in the Disk of M81: Tracing the Spatial Distribution of Star Formation 25 Million Years in the Past

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Near-infrared images, obtained with the CFHTIR imager on the Canada-France-Hawaii Telescope, are used to investigate the brightest red stars in the disk of the nearby spiral galaxy M81. Red supergiants (RSGs) form a well-defined sequence on the color-magnitude diagrams (CMDs) that peaks near $M_K = -11.5$; RSGs with this peak brightness are seen throughout all fields that were studied, indicating that star formation occured over a large part of the M81 disk

only ∼10 Myr in the past. The number of RSGs per unit integrated $K-$band light is compared at various locations in the disk. The number density of bright RSGs is similar in three of four fields, indicating that the bright RSGs tend to be well mixed with the older stellar populations that dominate the integrated light in the K-band. However, the density of bright RSGs in a northern disk field is ∼2 times higher than average, suggesting that the SFR in this part of the disk was higher than average 10 - 25 Myr in the past. The northern disk field contains areas of on-going star formation, and it is suggested that it is a region of prolonged star-forming activity. The number density of RSGs that formed during the past 10 - 25 Myr at galactocentric distances between ∼4 and 7 kpc is also comparable with that which formed between ∼7 and 10 kpc. We conclude that star-forming activity in M81 during the past 10 - 25 Myr (1) was distributed over a larger fraction of the disk than it is at the present day, and (2) was not restricted to a given radial interval, but was distributed in a manner that closely followed the stellar mass profile. Star counts indicate that the mean SFR of M81 between 10 and 25 Myr in the past was ∼0.1 $M_\odot$ year$^{-1}$, which is not greatly different from the present day SFR estimated from H$\alpha$ and FUV emission.

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# Optical spectroscopy of post-AGB carbon star CGCS 6857 = IRAS 20000+3239

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Using the echelle spectrograph PFES of the 6 m telescope, we obtained moderate resolution CCD-spectra of a post-AGB star CGCS 6857 associated with an IR-source IRAS 20000+3239 having a IR-feauture at 21 $\mu$m in emission. We revealed the bands of the $C_2$ and CN molecules, but no $C_3$, in the optical spectrum. The model atmospheric parameters adopted are: the effective temperature $T_{\rm eff} = 5000 \pm 200$ K, the logarithmic gravity $\log g = 0.0 \pm 0.3$ and the microturbulent velocity $\xi_{\rm t} = 9.0 \pm 1.0$ km s$^{-1}$. We obtained the low metallicity [Fe/H]=−1.4, the C/O-ratio close to 1 together with the large overabundances of *s*-process elements Y, Zr, Ba, La, Ce, Pr, Sm with the average value [El/Fe]=+1.4. The heliocentric radial velocity from metallic lines is equal to $v_{rad}(met) = -15 \pm 2$ km s$^{-1}$.

**Published in Baltic Astronomy, vol.15, p.395 (2006)**

# The Origin of Carbon-Enhancement and Initial Mass Function of Extremely Metal-Poor Stars in the Galactic Halo

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It is known that the carbon-enhanced, extremely metal-poor (CEMP) stars constitute a substantial proportion in the extremely metal-poor (EMP) stars of the Galactic Halo, by far larger than CH stars in Population II stars. We investigate their origin with taking into account an additional evolutionary path to the surface carbon-enrichment, triggered by hydrogen engulfment by the helium flash convection, in EMP stars of [Fe/H] $\lesssim -2.5$. This process is distinct from the third dredge-up operating in more metal-rich stars and also in EMP stars. In binary systems of EMP stars, the secondary stars become CEMP stars through mass transfer from the primary stars of low and intermediate masses, which have developed the surface carbon-enhancement. Our binary scenario can predict the

variations in the abundances not only for carbon but also for nitrogen and s-process elements and reasonably explain the observed properties such as the stellar distributions with respect to the carbon abundances, the binary periods, and the evolutionary stages. Furthermore, from the observed frequencies of CEMP stars with and without s-process element enhancement, we demonstrate that the initial mass function of EMP stars need to give the mean mass $\sim$10 $M_\odot$ under the reasonable assumptions on the distributions of orbital separations and mass ratio of binary components. This also indicates that the currently observed EMP stars were exclusively born as the secondary members of binaries, making up $\sim$10% remnants of EMP binary systems of mass $\sim 10^8$ $M_\odot$ in total; in addition to CEMP stars with white dwarf companions, a significant fraction of them have experienced supernova explosions of their companions. We discuss the implications of the present results in relation to the formation of Galactic halo.

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*Available from* astro-ph/0610670

# *Conference Paper*

## A New Look at the Empirical Initial-Final Mass Relation

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We examine new methods of producing and analyzing the empirical initial-final mass relation for open cluster white dwarfs (WDs). We re-determine initial and final masses for the complete sample of published cluster WDs and then pare this sample using stringent criteria. We create an empirical initial-final mass relation by binning all WDs in individual clusters to a single point. Despite potentially significant systematics arising from this approach, we are comfortable concluding that, to within current observational constraints, the initial-final mass relation is linear, any intrinsic scatter in the relation is $\lesssim$0.05 solar masses, and there is no metallicity dependence. More exploration of these issues is clearly warranted.

**Oral contribution, published in The 15$^{\rm th}$ European White Dwarf Workshop, to be published in ASP Conference Series**
*Available from* astro-ph/0610254

# *Review Papers*

## Planetary nebulae as probes of the chemical impact of AGB stars

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Planetary nebulae (PN) represent the evolutionary fate of the asymptotic giant branch (AGB) stellar envelopes, thus are ideally suited to study the chemical impact of AGB stars. Stellar evolution predict elemental enrichment through the AGB evolution, and convective dredge-up episodes allow the products of stellar evolution to reach the stellar outer layers. Planetary nebulae are probes of these processes, and are also probes of the environment at the time of formation of their progenitors, through the elements not affected by AGB evolution. Ultimately PN may be used to test AGB stars as actors and probes. Planetary nebulae are easily identified and detected in the galaxy, the Magellanic Clouds, and beyond, thus they are probes of AGB evolution an stellar populations in different environments as well.

**Published in "Why galaxies care about AGB stars", Vienna, August 7-11, 2006**
*Available from* astro-ph/0610206

## Binary central stars of planetary nebulae

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This paper reviews our knowledge on binary central stars of planetary nebulae and presents some personal opinions regarding their evolution. Three types of interactions are distinguished: type I, where the binary companion induces the mass loss; type II, where it shapes the mass loss but does not enhance it; type III, where a wide orbit causes the centre of mass to move, leading to a spiral embedded in the wind. Surveys for binary central stars are discussed, and the separations are compared to the distribution for binary post-AGB stars. The effect of close binary evolution on nebular morphology is discussed. Post-common-envelope binaries are surrounded by thin, expanding disks, expelled in the orbital plane. Wider binaries give rise to much thicker expanding torii. Type I binary evolution predicts a wide distribution of masses of central stars, skewed towards low masses. Comparison with observed mass distributions suggests that this is unlikely to be the only channel leading to the formation of a planetary nebula. A new sample of compact Bulge nebulae shows about 40% of nebulae with binary-induced morphologies.

**Published in 'Evolution and chemistry of symbiotic stars and related objects', Wierzba, August 2006. To appear in Baltic Astronomy**
*Available from* astro-ph/0610558

# *Job Adverts*

## Monash University, Australia
## Tenure-Track (Lecturer or Senior Lecturer)

Outstanding scientists are invited to apply for three continuing full-time Lectureships at Level B or C as appropriate. (Level B = Lecturer, or approx Asst. Prof.; Level C = Senior Lecturer, or approx Assoc. Prof.) We seek applications in any area of specialty in the School of Mathematics, including astrophysics. One appointment will be made in probability or statistics, another in pure mathematics and the third from any area of mathematical science that enhances the school's research profile (including astrophysics, both observational and theoretical). Applicants should have a PhD, an outstanding research record and proven teaching ability. Appointment will be made at a level appropriate to the successful applicant's qualifications, experience and in accordance with the classification standards for each level. Applicants must specifically address the selection criteria and should use the template available at http://www.maths.monash.edu.au/jobs/oct2006/ Salary range (AUD): $63,925-$75,912 / $78,309-$90,294 pa Level B/Level C plus generous superannuation

Location: Clayton campus

Contact: A/Prof. Alan Pryde on 9905 4417 or email Alan.Pryde@sci.monash.edu.au. or Prof John Lattanzio john.lattanzio@sci.monash.edu.au Ref No: A067135

Applications close: Wednesday, 15 November 2006

Applications: By email to the above contact or by mail addressed to Associate Professor Alan Pryde, Head, School of Mathematical Sciences, Monash University, Building 28, Clayton Vic 3800

*See also* http://sssd.adm.monash.edu.au/employ/job.asp?refnumber=A067135

# Dept. of Physics and Astronomy, University of Denver, USA
# Tenure-Track Position

The Department of Physics and Astronomy at the University of Denver would like to remind the readers of the AGB Newsletter that we are hiring of three tenure-track assistant professorships beginning September 2007, with a possibility to hire at the associate professor level, if exceptional candidates are identified. We expect to fill at least one of three positions by someone in the field of evolved star research. The selection process will begin on November 17, 2006, and continue until the positions are filled. Please consult http://www.physics.du.edu and http://www.dujobs.org for details. The University of Denver is committed to enhancing the diversity of its faculty and staff and encourages applications from women, minorities, people with disabilities and veterans. DU is an EEO/AA employer.

*See also* http://www.physics.du.edu