# THE AGB NEWSLETTER

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Editors: Jacco van Loon and Albert Zijlstra

## *Editorial*

Dear Colleagues,

It is our pleasure to present you the 147$^{\rm th}$ issue of the AGB Newsletter. Much recent interesting work concerns itself with planetary nebulae and their interaction with the surrounding interstellar medium, and with mass loss from carbon stars and from Halo field and globular cluster red giants. But that is not all — as you can see for yourself.

Last month's *Food for Thought* — on how typical is IRC +10 216 — evoked some reactions, from "It is your typical prototype object: as more and more is learned about it, it appears less and less like the type it spawned", and "In a visual/near-infrared photometric sense, this object started life in the literature like most carbon stars — very red, showing some signs of dusty mass loss when the IRAS data came back, an object of interest due to its extreme brightness. As a carbon star, it defied a really regular spectral typing (as all carbon stars do). However, when (very) high resolution observations started coming back — http://www.physics.usyd.edu.au/∼gekko/irc10216.html — it was clear there was all sorts of asymmetric morphology (and mass loss) associated with this object; there'll probably have to be complicated MHD and/or rotational dynamics associated with proper models to describe it all. Maybe this is a statement less of it separating itself out as being 'different', than one of it being a victim of information overload: the observations are well starting to outpace the models for this object..?", or "That was probably the dirst IR source I had observed as an undergrad with the TIRCAM camera at Gornergrat... It does have some peculiarities that are difficult to find in other carbon stars: (1) high mass-loss rate; (2) water vapour in the envelope (see SWAS results, attributed to 'evaporation' of comets in its former Kuiper Belt); (3) shells with $\sim$ 100 yr separation (as in the Mauron & Huggins images); (4) time dependent asymmetric outflows as in the Tuthill and Weigelt near-IR speckle and aperture mask data. However, all these features are not unique: (1) not so unusual for an 'evolved' carbon star; (2) expected for most stars, it is just easier to see in carbon stars because of the contrast in chemistry. Kuiper and asteroid belt remnants have been found around white dwarfs (Jura papers); (3) recent images (Mauron & Huggins 2006) found shells seen in scattered light among several other sources on the AGB and post-AGB, and there are several pre-PNe showing the same; (4) if all carbon stars were at $\sim$ 120 pc maybe we would find the same... So maybe it is not too peculiar after all" — indeed, those who believe in the Copernican Principle, would argue that IRC +10 216 *must* be typical of carbon stars, or at least not be unique.

There are also jobs: a postdoctoral position in Brussels to work on the exciting VISTA survey of the Magellanic Clouds, which is about to commence, and a PhD studentship in Amsterdam, to work with an extremely inspiring supervisor.

The next issue is planned to be distributed on the 1$^{\rm st}$ of November 2009.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

# *Food for Thought*

This month's thought-provoking statement is:

*Low-mass stars lose most of their mass near the tip of the first-ascent red giant branch.*

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*

## Shaping point- and mirror-symmetric protoplanetary nebulae by the orbital motion of the central binary system

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We present three-dimensional hydrodynamical simulations of a jet launched from the secondary star of a binary system inside a protoplanetary nebula. The secondary star moves around the primary in a close eccentric orbit. From the gasdynamic simulations we compute synthetic [N II] 6583 emission maps. Different jet axis inclinations with respect to the orbital plane, as well as different orientations of the flow with respect to the observer, are considered. For some parameter combinations, we obtain structures that show point-or mirror-symmetric morphologies depending on the orientation of the flow with respect to the observer. Furthermore, our models can explain some of the emission distribution asymmetries that are summarized in the classification given by Soker & Hadar.

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## Kinematics of the ring-like nebula SuWt 2

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We present the first detailed spatio-kinematical analysis and modelling of the Southern planetary nebula SuWt 2. This object presents a problem for current theories of planetary nebula formation and evolution, as it is not known to contain a central post-main sequence star.

Deep narrowband [N II] 6584 Å images reveal the presence of faint bipolar lobes emanating from the edges of the nebular ring. Longslit observations of the H$\alpha$ and [N II] 6584 Å emission lines were obtained using EMMI on the 3.6-m ESO-NTT. The spectra reveal the nebular morphology as a bright torus encircling the waist of an extended bipolar structure. By deprojection, the inclination of the ring is found to be $68^\circ \pm 2^\circ$ (c.f. $\sim 90^\circ$ for the double A-type binary believed to lie at the centre of the nebula), and the ring expansion velocity is found to be 28 km s$^{-1}$.

Our findings are discussed with relation to possible formation scenarios for SuWt 2. Through comparison of the nebular heliocentric systemic velocity, found here to be $-25 \pm 5$ km s$^{-1}$, and the heliocentric systemic velocity of the double A-type binary, we conclude that neither component of the binary could have been the nebular progenitor. However, we are unable to rule out the presence of a third component to the system, which would have been the nebula progenitor.

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*Available from* arXiv:0909.0448

# Results of infrared photometry and a model for the dust envelope of the protoplanetary nebula candidate V1027 Cyg

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Results of $JHKLM$ photometry for the protoplanetary nebula candidate V1027 Cyg obtained in 1991–2008 are reported. In all bands, the brightness variations did not exceed $0^{\rm m}.2$. Estimated linear trends demonstrate no significant changes in the mean brightness and color indices of the object, with the possible exception of the $L-M$ color index, which showed a small decrease. A search for possible periodicities in the brightness variations yielded the most probable period of $237^{\rm d}$. A model for a spherically-symmetric dust shell of silicate grains has been calculated based on the photometric results supplemented with data on the mid- and far-infrared fluxes. The best-fit model has a radius of the inner boundary of $3.02 \times 10^{15}$ cm, the dust temperature at this boundary of 565 K, the optical thickness of the shell at 0.55 $\mu$m of 0.36, and implies a distance to the star of 3470 pc. The estimated mass-loss rate of the star is $\dot{M} = 1.3 \times 10^{-5}$ M$_\odot$ yr$^{-1}$ .

**Accepted for publication in Astronomy Reports**

# The halos of Planetary Nebulae in the mid-infrared: Evidence for interaction with the interstellar medium

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The motion of planetary nebulae (PNe) through the interstellar medium (ISM) is thought to lead to a variety of observational consequences, including the formation of bright rims; deformation and fragmentation of the shells; and a shift of the central stars away from the geometric centres of the envelopes. These and other characteristics have been noted through imaging in the visual wavelength regime. We report further observations of such shells taken in the mid-infrared (MIR), acquired through programs of IRAC imaging undertaken using the Spitzer Space Telescope (SST).
NGC 2440 and NGC 6629 are shown to possess likely interacting halos, together with ram-pressure stripped material to one side of their shells. Similarly, the outer halos of NGC 3242 and NGC 6772 appear to have been fragmented through Rayleigh-Taylor (RT) instabilities, leading to a possible flow of ISM material towards the inner portions of their envelopes. If this interpretation is correct, then it would suggest that NGC 3242 is moving towards the NE; a suggestion which is also supported through the presence of a 60 $\mu$m tail extending in the opposite direction, and curved bands of H$\alpha$ emission in the direction of motion — components which may arise through RT instabilities in the magnetized ISM.

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## Rings and halos in the mid-infrared: The Planetary Nebulae NGC 7354 and NGC 3242

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We present images of the planetary nebulae (PNe) NGC 7354 and NGC 3242 in four mid-infrared (MIR) photometric bands centred at 3.6, 4.5, 5.8 and 8.0 $\mu$m; the results of observations undertaken using the Spitzer Space Telescope (SST). The resulting images show the presence of a halo and rings in NGC 3242, as previously observed through narrow band imaging at visual wavelengths, as well as evidence for a comparable halo and ring system in NGC 7354. This is the first time that a halo and rings have been observed in the latter source.
We have analysed the formation of halos as a result of radiatively accelerated mass loss in the AGB progenitors. Although the models assume that dust formation occurs in C-rich environments, we note that qualitatively similar results would be expected for O-rich progenitors as well. The model fall-offs in halo density are found to result in gradients in halo surface brightness which are similar to those observed in the visible and MIR.

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## Radiation pressure and pulsation effects on the Roche lobe

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Several observational pieces of evidence indicate that specific evolutionary channels which involve Roche lobe overflow are not correctly accounted for by the classical Roche model. We generalize the concept of Roche lobe in the presence of extra forces (caused by radiation pressure or pulsations). By computing the distortion of the equipotential surfaces, we are able to evaluate the impact of these perturbing forces on the stability of Roche-lobe overflow (RLOF). Radiative forces are parametrized through the constant reduction factor that they impose on the gravitational force from the radiating star (neglecting any shielding in case of large optical thickness). Forces imparted by pulsations are derived from the velocity profile of the wind that they trigger. We provide analytical expressions to compute the generalized Roche radius. Depending on the extra force, the Roche-lobe radius may either stay unchanged, become smaller, or even become meaningless (in the presence of a radiatively- or pulsation-driven wind). There is little impact on the RLOF stability.

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## The mid-infrared colours of Galactic Bulge, Disk and Magellanic Planetary Nebulae

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We present mid-infrared (MIR) photometry for 367 Galactic disk, bulge and Large Magellanic Cloud (LMC) planetary nebulae, determined using GLIMPSE II and SAGE data acquired using the Spitzer Space Telescope. This has permitted us to make a comparison between the luminosity functions of bulge and LMC planetary nebulae, and between the MIR colours of all three categories of source. It is determined that whilst the 3.6 $\mu$m luminosity function of

the LMC and bulge sources are likely to be closely similar, the [3.6]–[5.8] and [5.8]–[8-0] indices of LMC nebulae are different from those of their disk and bulge counterparts. This may arise because of enhanced 6.2 $\mu$m PAH emission within the LMC sources, and/or as a result of differences between the spectra of LMC PNe and those of their Galactic counterparts. We also determine that the more evolved disk sources listed in the MASH catalogues of Parker et al. and Miszalski et al. (2008) have similar colours to those of the less evolved (and higher surface brightness) sources in the catalogue of Acker et al. (1992); a result which appears at variance with previous studies of these sources.

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## Dust driven mass loss from carbon stars as function of stellar parameters — I. A grid of solar-metallicity wind models

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(Abridged) We have computed a grid of 900 numeric dynamic model atmospheres (DMAs) using a well-tested computer code. This grid of models covers most of the expected combinations of stellar parameters, which are the stellar temperature, the stellar luminosity, the stellar mass, the abundance of condensible carbon, and the velocity amplitude of the pulsation. The resultant mass-loss rates and wind speeds are clearly affected by the choice of stellar temperature, mass, luminosity and the abundance of available carbon. In certain parts of the parameter space there is also an inevitable mass-loss threshold, below which a dust-driven wind is not possible. Contrary to some previous studies, we find a strong dependence on the abundance of free carbon, which turns out to be a critical parameter. Furthermore, we have found that the dust grains that form in the atmosphere may grow too large for the commonly-used small-particle approximation of the dust opacity to be strictly valid. This may have some bearing on the wind properties, although further study of this problem is needed before quantitative conclusions can be drawn. The wind properties show relatively simple dependences on stellar parameters above the mass-loss threshold, while the threshold itself is of a more complicated nature. Hence, we chose not to derive any simplistic mass-loss formula, but rather provide a mass-loss prescription in the form of an easy-to-use FORTRAN routine. Since this mass-loss routine is based on data coming from an essentially self-consistent model of mass loss, it may therefore serve as a better mass-loss prescription for stellar evolution calculations than empirical formulae. Furthermore, we conclude that there are still some issues that need to be investigated, such as the role of grain-sizes.

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## Discovery of a close substellar companion to the hot subdwarf star HD 149382 — The decisive influence of substellar objects on late stellar evolution

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Substellar objects, like planets and brown dwarfs orbiting stars, are by-products of the star formation process. The evolution of their host stars may have an enourmous impact on these small companions. Vice versa a planet might also influence stellar evolution as has recently been argued.
Here we report the discovery of a 8–23 Jupiter-mass substellar object orbiting the hot subdwarf HD 149382 in 2.391 days at a distance of only about five solar radii. Obviously the companion must have survived engulfment in the red-giant envelope. Moreover, the substellar companion has triggered envelope ejection and enabled the sdB star to form. Hot subdwarf stars have been identified as the sources of the unexpected ultravoilet emission in elliptical galaxies, but

the formation of these stars is not fully understood. Being the brightest star of its class, HD 149382 offers the best conditions to detect the substellar companion. Hence, undisclosed substellar companions offer a natural solution for the long-standing formation problem of apparently single hot subdwarf stars. Planets and brown dwarfs may therefore alter the evolution of old stellar populations and may also significantly affect the UV-emission of elliptical galaxies.

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## Near-IR spectra of IPHAS extremely red Galactic AGB stars

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We present a library of 139 near-IR spectra of cool asymptotic giant branch stars that will be useful for comparison with theoretical model atmosphere calculations and for modeling the integrated emission from intermediate-age stellar populations. The source list was selected from the 'extremely red' region of the INT Photometric H Alpha Survey (IPHAS) colour–colour plane that is overwhelmingly dominated by very late-type stars. The spectral library also includes a large fraction of S-type and carbon stars. We present a number of spectral classification sequences highlighting the various molecular features identified and discuss a number of rare features with uncertain identifications in the literature. With its focus on particularly cool photospheres this catalogue serves as a companion to recent spectroscopic atlases of MK standards in the near-IR. Finally the relationship between IPHAS $(r' - i')$ and $(r' - \mathrm{H}\alpha)$ colours and spectroscopically determined properties is discussed and a strong correlation between $(r' - \mathrm{H}\alpha)$ colour and the C/O abundance index for S-type and carbon stars is noted. This relation has the potential to separate O-rich, S-type and carbon stars in the Galaxy based on their photometry alone.

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## The masses of population II White Dwarfs

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Globular star clusters are among the first stellar populations to have formed in the Milky Way, and thus only a small sliver of their initial spectrum of stellar types are still burning hydrogen on the main-sequence today. Almost all of the stars born with more mass than 0.8 $\mathrm{M}_{\odot}$ have evolved to form the white dwarf cooling sequence of these systems, and the distribution and properties of these remnants uniquely holds clues related to the nature of the now evolved progenitor stars. With ultra-deep HST imaging observations, rich white dwarf populations of four nearby Milky Way globular clusters have recently been uncovered, and are found to extend an impressive 5–8 magnitudes in the faint-blue region of the H-R diagram. In this paper, we characterize the properties of these population II remnants by presenting the first direct mass measurements of individual white dwarfs near the tip of the cooling sequence in the nearest of

the Milky Way globulars, M 4. Based on Gemini/GMOS and Keck/LRIS multiobject spectroscopic observations, our results indicate that 0.8 $M_\odot$ population II main-sequence stars evolving today form $0.53 \pm 0.01$ $M_\odot$ white dwarfs. We discuss the implications of this result as it relates to our understanding of stellar structure and evolution of population II stars and for the age of the Galactic halo, as measured with white dwarf cooling theory.

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## Changes in the red giant and dusty environment of the recurrent nova RS Ophiuchi following the 2006 eruption

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We present near infrared spectroscopy of the recurrent nova RS Oph obtained on several occasions after its latest outburst in 2006 February. The 1–5 $\mu$m spectra are dominated by the red giant, but the H I, He I, and coronal lines present during the eruption are present in all our observations. From the fits of the computed infrared spectral energy distributions to the observed fluxes we find $T_{\rm eff} = 4200 \pm 200$ K for the red giant. The first overtone CO bands at 2.3 $\mu$m, formed in the atmosphere of the red giant, are variable. The spectra clearly exhibit an infrared excess due to dust emission longward of 5 $\mu$m; we estimate an effective temperature for the emitting dust shell of 500 K, and find that the dust emission is also variable, being beyond the limit of detection in 2007. Most likely, the secondary star in RS Oph is intrinsically variable.

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## Wind-swept clouds and possible triggered star-formation associated with the Supernova Remnant G 357.7+0.3

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We present evidence for interaction between the supernova remnant (SNR) G 357.7+0.3 and nearby molecular clouds, leading to the formation of wind-swept structures and bright emission rims. These features are not observed at visual wavelengths, but are clearly visible in mid-infrared (MIR) mapping undertaken using the Spitzer Space Telescope (SST). Analysis of one of these clouds, the bright cometary structure G 357.46+0.60, suggests that it contains strong polycyclic aromatic hydrocarbon (PAH) emission features in the 5.8 and 8.0 $\mu$m photometric bands, and that these are highly variable over relatively small spatial scales. This source also appears to contain a YSO within the bright rim structure, with a steeply rising spectrum between 1.25 and 24 $\mu$m.
Finally, it is noted that a further, conical emission region appears to be associated with the Mira V1139 Sco, and it is suggested that this may represent the case of a Mira outflow interacting with a SNR.

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# New evolutionary sequences for hot H-deficient white dwarfs on the basis of a full account of progenitor evolution

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We present full evolutionary calculations appropriate for the study of hot hydrogen-deficient DO white dwarfs, PG 1159 stars, and DB white dwarfs. White dwarf sequences are computed for a wide range of stellar masses and helium envelopes on the basis of a complete treatment of the evolutionary history of progenitors stars, including the core hydrogen and helium burning phases, the thermally-pulsing AGB phase, and the born-again episode that is responsible for the hydrogen deficiency. We also provide colors and magnitudes for the new sequences for $T_{\rm eff} < 40\,000$ K, where the NLTE effects are not dominant. These new calculations provide an homogeneous set of evolutionary tracks appropriate for mass and age determinations for both PG 1159 stars and DO white dwarfs. The calculations are extended down to an effective temperature of 7 000 K. We applied these new tracks to redetermine stellar masses and ages of all known DO white dwarfs with spectroscopically-determined effective temperatures and gravities, and compare them with previous results. We also compare for the first time consistent mass determinations for both DO and PG 1159 stars, and find a considerably higher mean mass for the DO white dwarfs. We discuss as well the chemical profile expected in the envelope of variable DB white dwarfs from the consideration of the evolutionary history of progenitor stars. Finally, we present tentative evidence for a different evolutionary channel, other than that involving the PG 1159 stars, for the formation of hot, hydrogen-deficient white dwarfs.

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# Fast winds and mass loss from metal-poor field giants

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Echelle spectra of the infrared He I $\lambda$10830 line were obtained with NIRSPEC on the Keck 2 telescope for 41 metal-deficient field giant stars including those on the red giant branch (RGB), asymptotic giant branch (AGB), and red horizontal branch (RHB). The presence of this He I line is ubiquitous in stars with $T_{\rm eff} \gtrsim 4500$ K and $M_{\rm V}$ fainter than $-1.5$ mag, and reveals the dynamics of the atmosphere. The line strength increases with effective temperature for $T_{\rm eff} \gtrsim 5300$ K in RHB stars. In AGB and RGB stars, the line strength increases with luminosity. Fast outflows ($\geq 60$ km s$^{-1}$) are detected from the majority of the stars and about 40% of the outflows have sufficient speed as to allow escape of material from the star as well as from a globular cluster. Outflow speeds and line strengths do not depend on metallicity for our sample ([Fe/H] $= -0.7$ to $-3.0$) suggesting the driving mechanism for these winds derives from magnetic and/or hydrodynamic processes. Gas outflows are present in every luminous giant, but are not detected in all stars of lower luminosity indicating possible variability. Mass-loss rates ranging from $\sim 3 \times 10^{-10}$ to $\sim 6 \times 10^{-8}$ M$_\odot$ yr$^{-1}$ estimated from the Sobolev approximation for line formation represent values with evolutionary significance for red giants and red horizontal branch stars. We estimate that 0.2 M$_\odot$ will be lost on the red giant branch, and the torque of this wind can account for observations of slowly rotating RHB stars in the field. About 0.1–0.2 M$_\odot$ will be lost on the red horizontal branch itself. This first empirical determination of mass loss on the RHB may contribute to the appearance of extended horizontal branches in globular clusters. The spectra appear to resolve the problem of

missing intracluster material in globular clusters. Opportunities exist for 'wind smothering' of dwarf stars by winds from the evolved population, possibly leading to surface pollution in regions of high stellar density.

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## A self-consistent stellar and 3D nebular model for Planetary Nebula IC 418

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We present a coherent stellar and nebular model reproducing the observations of the Planetary Nebula IC 418. We want to test whether a stellar model obtained by fitting the stellar observations is able to satisfactory ionize the nebula and reproduce the nebular observations, which is by no mean evident. This allows us to determine all the physical parameters of both the star and the nebula, including the abundances and the distance. We used all the observational material available (FUSE, IUE, STIS and optical spectra) to constrain the stellar atmosphere model performed using the CMFGEN code. The photoionization model is done with Cloudy_3D, and is based on CTIO, Lick, SPM, IUE and ISO spectra as well as HST images. More than 140 nebular emission lines are compared to the observed intensities. We reproduce all the observations for the star and the nebula. The 3D morphology of the gas distribution is determined. The effective temperature of the star is 36.7kK. Its luminosity is 7700 $L_{\odot}$. We describe an original method to determine the distance of the nebula using evolutionary tracks. No clumping factor is need to reproduce the age–luminosity relation. The distance of 1.25 kpc is found in very good agreement with recent determination using parallax method. The chemical composition of both the star and the nebula are determined. Both are Carbon-rich. The nebula presents evidence of depletion of elements Mg, Si, S, Cl (0.5 dex lower than solar) and Fe (2.9 dex lower than solar). This is the first self-consistent stellar and nebular model for a Planetary Nebula that reproduces all the available observations ranging from IR to UV, showing that the combined approach for the modeling process leads to more restrictive constraints and, in principle, more trustworthy results.

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## NGC 300 OT2008-1 as a scaled-down version of the $\eta$ Carinae Great Eruption

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We propose that the intermediate luminosity optical transient NGC 300 OT2008-1 was powered by a mass transfer episode from an extreme Asymptotic Giant Branch star to a Main Sequence companion. We find a remarkable similarity of the shapes of the light curves of the several months long NGC 300 OT2008-1 outburst, of the three months long 2002 enigmatic outburst of the B star V838 Mon, and the twenty-years long Great Eruption of the massive binary system $\eta$ Carinae that occurred in the $19^{\rm th}$ century. Their similar decline properties hint to a common energy source: a gravitational energy that is released by accretion onto a main sequence star. These events populate a specific strip in the total energy vs. outburst duration diagram. The strip is located between novae and supernovae. We add recent transient events to that diagram and find them to occupy the same strip. This suggests that some intermediate luminosity optical transients are powered by accretion onto a compact object (not necessarily a main sequence star). These transients are expected to produce bipolar ejecta as a result of the geometry of the accretion process.

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# MSX versus IRAS two–color diagrams and the CSE-sequence of oxygen-rich late-type stars

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We present MSX two–color diagrams that can be used to characterize circumstellar environments of sources with good quality MSX colors in terms of IRAS color regions for oxygen-rich stars. With these diagrams we aim to provide a new tool that can be used to study circumstellar environments and to improve detection rates for targeted surveys for circumstellar maser emission similar to the IRAS two–color diagram. This new tool is especially useful for regions in the sky where IRAS was confused, in particular in the Galactic plane and bulge region. Unfortunately, using MSX colors alone does not allow to distinguish between carbon-rich and oxygen-rich objects. An application of this tool on 86 GHz SiO masers shows that for this type of masers an instantaneous detection rate of 60% to 80% can be achieved if target sources are selected according to MSX color (region).
Our investigations may have revealed an error in the MSX point source catalog version 2.3. That is, the photometry of the 21.3 $\mu$m (MSX E filter) band for most weak 8.28 $\mu$m (or MSX A filter) band sources seems off by about a factor two (0.5–1 magnitude too bright).

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# The chemical composition of carbon stars: The R-type stars

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The aim of this work is to shed some light on the problem of the formation of carbon stars of R-type from a detailed study of their chemical composition. We use high-resolution and high signal-to-noise optical spectra of 23 R-type stars (both early- and late-types) selected from the Hipparcos catalogue. The chemical analysis is made using spectral synthesis in LTE and state-of-the-art carbon-rich spherical model atmospheres. We derive their CNO content (including the $^{12}C/^{13}C$ ratio), average metallicity, lithium, and light (Sr, Y, Zr) and heavy (Ba, La, Nd, Sm) *s*-element abundances. The observed properties of the stars (galactic distribution, kinematics, binarity, photometry and luminosity) are also discussed. Our analysis shows that late-R stars are carbon stars with identical chemical and observational characteristics as the normal (N-type) AGB carbon stars. In fact, the *s*-element abundance pattern derived can be reproduced by low-mass AGB nucleosynthesis models where the $^{13}C(\alpha, n)^{16}O$ reaction is the main neutron donor. We confirm the results of the sole previous abundance analysis of early-R stars by Dominy (1984), namely: they are carbon stars with near solar metallicity showing enhanced nitrogen, low $^{12}C/^{13}C$ ratios and no *s*-element enhancements. In addition, we have found that early-R stars have Li abundances larger than expected for post RGB tip giants. We also find that a significant number ($\sim 40\%$) of the early-R stars in our sample are wrongly classified, being probably classical CH stars and normal K giants. On the basis of the chemical analysis, we confirm the previous suggestion that late-R stars are just misclassified N-type carbon stars in the AGB phase of evolution. Their photometric, kinematic, variability and luminosity properties are also compatible with this. In consequence, we suggest that the number of true R stars is considerably lower than previously believed. This alleviates the problem of considering R stars as a frequent stage in the evolution of low-mass stars. We briefly discuss the different scenarios proposed for the formation of early-R stars. The mixing of carbon during an anomalous He-flash is favoured, although no physical mechanism able to trigger that mixing has been found yet. The origin of these stars still remains a mystery.

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# Rb-rich Asymptotic Giant Branch stars in the Magellanic Clouds

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We present high-resolution ($R \sim 60,000$) optical spectra of a carefully selected sample of heavily obscured and presumably massive O-rich Asymptotic Giant Branch (AGB) stars in the Magellanic Clouds (MCs). We report the discovery of strong Rb I lines at 7800 Å in four Rb-rich LMC stars at luminosities equal to or greater than the standard adopted luminosity limit for AGB stars ($M_{\rm bol} \sim -7.1$), confirming that "Hot Bottom Burning" (HBB) may produce a flux excess in the more massive AGB stars. In the SMC sample, just one of the five stars with $M_{\rm bol} < -7.1$ was detected in Rb; the other stars may be massive red supergiants. The Rb-rich LMC AGB stars might have stellar masses of at least $\sim$ 6–7 $M_\odot$. Our abundance analysis show that these Rb-rich stars are extremely enriched in Rb by up to $10^3$–$10^5$ times solar but seem to have only mild Zr enhancements. The high Rb/Zr ratios, if real, represent a severe problem for the *s*-process, even if the $^{22}$Ne source is operational as expected for massive AGB stars; it is not possible to synthesize copious amounts of Rb without also overproducing Zr. The solution to the problem may lie with an incomplete present understanding of the atmospheres of luminous AGB stars.

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*and from* http://www.iac.es/folleto/research/preprints/?c=view&pre_id=9052

# Dust production and mass loss in the Galactic globular cluster NGC 362

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We investigate dust production and stellar mass loss in the Galactic globular cluster NGC 362. Due to its close proximity to the Small Magellanic Cloud (SMC), NGC 362 was imaged with the IRAC and MIPS cameras onboard the Spitzer Space Telescope as part of the Surveying the Agents of Galaxy Evolution (SAGE-SMC) Spitzer Legacy program. We detect several cluster members near the tip of the Red Giant Branch that exhibit infrared excesses indicative of circumstellar dust and find that dust is not present in measurable quantities in stars below the tip of the Red Giant Branch. We modeled the spectral energy distribution (SED) of the stars with the strongest IR excess and find a total cluster dust mass-loss rate of $3.0^{+2.0}_{-1.2} \times 10^{-9}$ $M_\odot$ yr$^{-1}$, corresponding to a gas mass-loss rate of $8.6^{+5.6}_{-3.4} \times 10^{-6}$ $M_\odot$ yr$^{-1}$, assuming [Fe/H] = −1.16. This mass loss is in addition to any dust-less mass loss that is certainly occurring within the cluster. The two most extreme stars, variables V2 and V16, contribute up to 45% of the total cluster dust-traced mass loss. The SEDs of the more moderate stars indicate the presence of silicate dust, as expected for low-mass, low-metallicity stars. Surprisingly, the SED shapes of the stars with the strongest mass-loss

rates appear to require the presence of amorphous carbon dust, possibly in combination with silicate dust, despite their oxygen-rich nature. These results corroborate our previous findings in $\omega$ Centauri.

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# *Conference Papers*

## The CIFIST 3D model atmosphere grid

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Grids of stellar atmosphere models and associated synthetic spectra are numerical products which have a large impact in astronomy due to their ubiquitous application in the interpretation of radiation from individual stars and stellar populations. 3D model atmospheres are now on the verge of becoming generally available for a wide range of stellar atmospheric parameters. We report on efforts to develop a grid of 3D model atmospheres for late-type stars within the CIFIST Team at Paris Observatory. The substantial demands in computational and human labor for the model production and post-processing render this apparently mundane task a challenging logistic exercise. At the moment the CIFIST grid comprises 77 3D model atmospheres with emphasis on dwarfs of solar and sub-solar metallicities. While the model production is still ongoing, first applications are already worked upon by the CIFIST Team and collaborators.

**Poster contribution, published in IAU General Assembly Joint Discussion 10 "3D views on cool stellar atmospheres: theory meets observation"; to appear in a dedicated volume of the "Memorie della Società Astronomica Italiana"**
*Available from* arXiv:0908.4496

## The connection between pulsation, mass loss and circumstellar shells in Classical Cepheids

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Recent observations of Cepheids using infrared interferometry and Spitzer photometry have detected the presence of circumstellar envelopes (CSE) of dust and it has been hypothesized that the CSE's are due to dust forming in a Cepheid wind. Here we use a modified Castor, Abbott & Klein formalism to produce a Cepheid wind, and this is used to estimate the contribution of mass loss to the Cepheid mass discrepancy Furthermore, we test the OGLE-III Classical Cepheids using the IR fluxes from the SAGE survey to determine if Large Magellanic Cloud Cepheids have CSEs. It is found that IR excess is a common phenomenon for LMC Cepheids and that the resulting mass-loss rates

can explain at least a fraction of the Cepheid mass discrepancy, depending on the assumed dust-to-gas ratio in the wind.

**Oral contribution, published in "Stellar Pulsation: Challenges for Theory and Observations", Santa Fe, 2009**
*Available from* arXiv:0908.4591

## Abundance analysis of the Halo giant HD 122563 with three-dimensional model stellar atmospheres

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We present a preliminary local thermodynamic equilibrium (LTE) abundance analysis of the template halo red giant HD 122563 based on a realistic, three-dimensional (3D), time-dependent, hydrodynamical model atmosphere of the very metal-poor star. We compare the results of the 3D analysis with the abundances derived by means of a standard LTE analysis based on a classical, 1D, hydrostatic model atmosphere of the star. Due to the different upper photospheric temperature stratifications predicted by 1D and 3D models, we find large, negative, 3D-1D LTE abundance differences for low-excitation OH and Fe I lines. We also find trends with lower excitation potential in the derived Fe LTE abundances from Fe I lines, in both the 1D and 3D analyses. Such trends may be attributed to the neglected departures from LTE in the spectral line formation calculations.

**Oral contribution, published in Joint Discussion 10 at IAU General Assembly 2009 (Rio de Janeiro, Brazil)**
*Available from* arXiv:0909.0690

# *Job Adverts* smallskip

## post-doctoral position

*Background*

VISTA is a 4-m class wide field survey telescope for the southern hemisphere, equipped with a large near infrared camera. VISTA is going through commissioning and science verification right now.

During the first few years of operation VISTA will exclusively be used to carry out previously selected "public surveys" that aim at addressing fundamental questions in astrophysics today. One of these is the VISTA Magellanic Cloud (VMC) survey, which will observe the entire Magellanic Cloud system (180 square degrees) in $YJK$ (for details see http://star.herts.ac.uk/~mcioni/vmc/). The main aims are to study the spatially resolved Star Formation History (SFH) and the 3D structure of and interaction between the MC subsystems.

At the Royal Observatory there is a vacancy for a postdoctoral researcher to work on the analysis of the tens of thousands late-type stars (AGB stars) that will be detected with VMC. Combining the VMC data with other photometric catalogs (optical, other NIR, Spitzer, Akari, Herschel) will allow their Spectral Energy Distributions to be constructed and then modelled in a quantitative way.

In such a way a detailed study of the mass-loss process and AGB evolution as a function of environment over the MC will be possible for the first time.

The $K$-band data of VMC will be obtained over a 6 month period. This will allow the detection of Long Period Variables, and opens the possibility of combining this data with data from the MACHO and OGLE microlensing surveys. Studying the period distribution of LPVs/AGB stars over the MC will shed important light on the star formation history over the MC system.

*Profile*

PhD in astrophysics at the time the position is taken. Knowledge or familiarity with one or more of the following areas: AGB stars and their evolution, (dust) radiative transfer modelling, Virtual Observatory techniques (e.g., cross-correlation), data reduction of near-infrared (survey) data.

*Employment*

Starting date: January 1$^{st}$, 2010, or as soon as possible thereafter. The position is initially for two years, but an extension of two years is possible. The duty station is the Royal Observatory of Belgium, which is situated in the south of Brussels. Salary and other benefits are according to the salary scales of the Federal Government.

*Applications*

The application, including a CV, publication list, description of research interest, and the names and contact details of two professional references that may be contacted, should be sent electronically to Dr. Martin Groenewegen (marting@oma.be). The position will remain open until filled, but applications received by November 15$^{th}$ will receive first consideration.

*See also* http://homepage.oma.be/marting/Aktie1_vacature.pdf

# PhD position 'Unravelling the physical and chemical structure of the stellar winds in AGB stars'

**Background**
The late stages of stellar evolution of low- and intermediate-mass stars on the Asymptotic Giant Branch (AGB) are characterized by prodigious mass loss via a molecular, dusty wind. These winds dominate the final phases of the star and are important in the cycle of mass in galaxies. Understanding these stellar winds, their chemistry and time variation is one of the challenges of present-day AGB research. Recent observational studies of the mass loss history of AGB stars using both dust and gas give puzzling results, that suggest that the structure of these winds is not understood. For instance, the dust which condenses in the outflow is believed to be important in driving the stellar wind, but at present there is no good understanding of the importance of dust in driving oxygen-rich outflows. A possible alternative for driving the winds is radiation pressure on gas. Molecules such as CO and water are important coolants of the gas flow, and their rich infrared and millimeter spectra can be used to probe the physical and chemical structure of the outflow.

**The project**
In May of 2009, the ESA HERSCHEL Space Observatory was launched successfully, with three scientific instruments on board. The HIFI instrument on board of HERSCHEL will be used to study a large sample of AGB stars within the context of the approved guaranteed time key programme HIFISTARS. The project focuses on an observational analysis of molecular line observations (mainly of CO and water) that will be obtained using HIFI; these data will be combined with data taken in the context of other approved HERSCHEL programmes using the HERSCHEL PACS instrument and with archival data at other wavelengths to obtain a comprehensive view of the physical and chemical

structure of AGB winds. A significant part of the thesis work will involve modeling the HIFI and PACS observations us- ing state of the art radiative transfer models developed at the Institute of Astronomy of Leuven University by Dr. Leen Decin. The project will thus involve close collaboration with the Leuven institute, as well as with the HIFI expertise centre at Groningen.

**The position**
The position offered is a four year PhD limited term position funded through a NWO "vrije com- petitie" grant. The research will be conducted at the Astronomical Institute "Anton Pannekoek" of the University of Amsterdam, in close collaboration with the Institute for Astronomy of Leuven University, Belgium. Supervisors will be Prof.Dr. Rens Waters and Dr. Leen Decin. Salaries will be commensurate to the standard scale for PhD students at the University of Amsterdam. The candidate is expected to contribute to the teaching of astronomy courses at the University of Amsterdam.

**Interested?**
The successful candidate must have a master degree in astrophysics, physics or equivalent. Applications should be sent to Rens Waters (waters@uva.nl) and must include a CV and statement of research interests; please also arrange for two letters of reference (to be sent directly). Applications must arrive before October 15, 2009 or until the position is filled. For more information please contact Rens Waters (waters@uva.nl) or Leen Decin (leen@ster.kuleuven.be).

*See also* http://www.astro.uva.nl/