# 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 126$^{\rm th}$ issue of the AGB Newsletter, full of exciting new results. Also, don't miss the job advert for a postdoc at Cornell, and the announcement for a conference on polarimetry.

Congratulations to Evelien Vanhollebeke for her very interesting Ph.D. thesis!

Last month's "Food for Thought" was inspired by a discussion at the recent Torino workshop in Perugia, where John Lattanzio remarked that Cool Bottom Processing is a misnomer, as it's neither cool nor at the bottom of anything. But what *should* we call it? Stefan Uttenthaler sent us this summary and suggestion:

*"Naming is an important issue in science, and we should find a consensus on what term we are using for a certain phenomenon. I think we should use this occasion to agree once and forever on a single name for slow mixing phenomena below the convective envelope that are not described by standard convection theories.*

*I'm a young scientist and can only guess that the name "Cool Bottom Processing" for these phenomena was "historically" derived from the fact that the temperatures involved are lower than that in "Hot Bottom Burning" (HBB). However, the word "cool" in this context is somewhat misleading. Although I used the term CBP myself in a recent paper, I think we should not go on using this term.*

*Also "Deep Mixing" is not a good term to me, because the convective thermal pulse is also deep inside the star, but is well described by standard convection theory.*

*Roberto Gallino emphasized that there might be different physical mechanisms at play and we might even call it "Extra Mixings". Also, additional mixing mechanisms not yet described may be at work in other regions of the star, or in evolutionary states other than the AGB. For this reason, "Extra Mixing" as well as "Non-standard Mixing" is not precise enough.*

*We probably need a new generic name for this phenomenon, accounting for the absence of information on the physical cause of the required mass circulation. I would therefor suggest the name "Extended Envelope Mixing". As soon as there is information on the physical cause of it, we may design a more specific name for this phenomenon."*

The next issue will be distributed on the 3$^{\rm rd}$ of January; the deadline for contributions is the 2$^{\rm nd}$ of January. Note that you may find it impossible to contact us in the two weeks leading up to that day; the webform, on the other hand, does not take holidays and should work just fine. Happy Holidays!

Editorially Yours,
Jacco van Loon and Albert Zijlstra

# *Food for Thought*

This month's thought-provoking statement is:

*What is usually referred to as "Cool Bottom Processing" or "Extra/Deep/Non-standard Mixing" should be called "Extended Envelope Mixing".*

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*

## Three-component modeling of C-rich AGB star winds IV. Revised interpretation with improved numerical descriptions

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Models describing dust-driven winds are important for understanding the physical mechanism and properties of mass loss on the asymptotic giant branch. These models are becoming increasingly realistic with more detailed physics included, but also more computationally demanding. The purpose of this study is to clarify to what extent the applied numerical approach affects resulting physical structures of modelled winds, and to discuss resulting changes. Following the previously developed radiation hydrodynamic model – which includes descriptions for time-dependent dust formation and gas-dust drift - and using its physical assumptions and parameters, numerical improvements are introduced. Impacts of the so-called adaptive grid equation and advection schemes are assessed from models calculated with different numerical setups. Results show that wind models are strongly influenced by numerical imprecision, displaying differences in calculated physical properties of up to one hundred per cent. Using a non-adaptive grid, models become periodic (in multiples of stellar pulsation periods), instead of irregular, as obtained previously. Furthermore, the numerical improvements reveal changes in physical structures. The influence of gas-dust drift is confirmed to be highly important, in particular for the dust component. Gas and dust are less tightly coupled than previously, and drastically larger amounts of dust form assuming drift.

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## The hydrogen-deficient knot of the 'born again' planetary nebula Abell 58 (V605 Aql)

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We have analysed deep optical spectra of the 'born-again' planetary nebula Abell 58 and its hydrogen-deficient knot, surrounding V605 Aql, which underwent a nova-like eruption in 1919. Our analysis shows that the extinction towards

the central knot is much higher than previously thought, with $c(\mathrm{H}\beta)$=2.0. The outer nebula is less reddened, with $c(\mathrm{H}\beta)$=1.04. We find that the outer nebula has a Ne/O ratio higher than the average PN value.
The electron temperature we derive for the central knot varies widely depending on the diagnostic used. The [O III] nebular-to-auroral transition ratio gives a temperature of 20 800 K, while the ratio of the [N II] nebular and auroral lines give $T_{\mathrm{e}}$=15 200 K. The helium line ratios $\lambda$5876/$\lambda$4471 and $\lambda$6678/$\lambda$4471 imply temperatures of 350 K and 550 K respectively. Weakly temperature-sensitive O II recombination line ratios imply similarly low electron temperatures. Abundances derived from recombination lines are vastly higher than those found from collisionally excited lines, with the abundance discrepancy factor (adf) for $O^{2+}$ reaching 89 — the second highest known value after that found for the hydrogen deficient knots in Abell 30. The observed temperature diagnostics and abundances support the idea that, like Abell 30, the knot of Abell 58 contains some very cold ionised material. Although the central star is carbon-rich (C/O>1), the knot is found to be oxygen-rich, a situation not predicted by the single-star 'born again' theory of its formation.
We compare the known properties of Abell 58 to those of Abell 30, Sakurai's Object and several novae and nova remnants. We argue that the abundances in the ejecta observed in A 30 and A 58 have more in common with neon novae than with Sakurai's Object, which is believed to have undergone a final helium flash. In particular, the C/O ratio of less than unity and presence of substantial quantities of neon in the ejecta of both Abell 30 and Abell 58 are not predicted by very late thermal pulse models.

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## An abundance analysis of bright giants in the globular cluster NGC 1851

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We present the chemical compositions for eight bright giants in the globular cluster NGC 1851. Our analysis reveals large star-to-star abundance variations and correlations of the light elements O, Na, and Al, a feature found in every well studied globular cluster. However, NGC 1851 also exhibits large star-to-star abundance variations of the s-process elements Zr and La. These s-process elements are correlated with Al, and anticorrelated with O. Furthermore, the Zr and La abundances appear to cluster around two distinct values. A recent study revealed a double subgiant branch in NGC 1851. Our data reinforce the notion that there are two stellar populations in NGC 1851 and indicate that this cluster has experienced a complicated formation history with similarities to $\omega$ Centauri.

**Accepted for publication in ApJ Letters**
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## High-resolution spectroscopy of the R Coronae Borealis Star V Coronae Australis

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Optical high-resolution spectra of the R Coronae Borealis star V CrA at light maximum and during minimum light are discussed. Abundance analysis confirms previous results showing that V CrA has the composition of the small subclass of R Coronae Borealis (RCB) stars know as 'minority' RCBs, i.e., the Si/Fe and S/Fe ratios are 100 times their solar values. A notable novel result for RCBs is the detection of the 1-0 Swan system $^{12}C^{13}C$ bandhead indicating that $^{13}C$ is abundant: spectrum synthesis shows that $^{12}C/^{13}C$ is about 3 to 4. Absorption line profiles are variable at

maximum light with some lines showing evidence of splitting by about 10 km $s^{-1}$. A spectrum obtained as the star was recovering from a deep minimum shows the presence of cool $C_2$ molecules with a rotational temperature of about 1200K, a temperature suggestive of gas in which carbon is condensing into soot. The presence of rapidly outflowing gas is shown by blue-shifted absorption components of the Na I D and K I 7698 Å resonance lines.

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## Fluorine in R Coronae Borealis Stars

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Neutral fluorine (F I) lines are identified in the optical spectra of several R Coronae Borealis stars (RCBs) at maximum light. These lines provide the first measurement of the fluorine abundance in these stars. Fluorine is enriched in some RCBs by factors of 800 to 8000 relative to its likely initial abundance. The overabundances of fluorine are evidence for the synthesis of fluorine. These results are discussed in the light of the scenario that RCBs are formed by accretion of an He white dwarf by a C-O white dwarf. Sakurai's object (V4334 Sgr), a final He-shell flash product, shows no detectable F I lines.

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## Inhibition of thermohaline mixing by a magnetic field in Ap star descendants: Implications for the Galactic evolution of $^3$He

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To reconcile the measurements of $^3$He/H in Galactic H II regions with high values of $^3$He in a couple of planetary nebulae, we propose that thermohaline mixing is inhibited by a fossil magnetic field in red giant stars that are descendants of Ap stars. We examine the effect of a magnetic field on the salt-finger instability, using a local analysis. We obtain a threshold for the magnetic field of $10^4 - 10^5$ Gauss, above which it inhibits thermohaline mixing in red giant stars located at or above the bump. Fields of that order are expected in the descendants of the Ap stars, taking into account the contraction of their core. We conclude that in a large fraction of the descendants of Ap stars thermohaline mixing does not occur. As a consequence these objects must produce $^3$He as predicted by the standard theory of stellar evolution and as observed in the planetary nebulae NGC 3242 and J 320. The relative number of such stars with respect to non-magnetic objects that undergo thermohaline mixing is consistent with the statistical constraint coming from observations of the carbon isotopic ratio in red giant stars. It also satisfies the Galactic requirements for the evolution of the $^3$He abundance.

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## MASH-II: More Planetary Nebulae from the AAO/UKST H$\alpha$ Survey

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We present a supplement to the Macquarie/AAO/Strasbourg H$\alpha$ planetary nebulae (PNe) catalogue (MASH), which we denote MASH-II. The supplement consists of over 300 true, likely and possible new Galactic PNe found after re-examination of the entire AAO/UKST H$\alpha$ survey of the southern Galactic Plane in digital form. We have spectroscopically confirmed over 240 of these new candidates as bona-fide PNe and we include other high quality candidates awaiting spectroscopic confirmation as possible PNe. These latest discoveries largely comprise two distinct groups: small, star-like or moderately resolved PNe at one end and mostly large, extremely low surface brightness PNe at the other. Neither group were easy to discover from simple visual scrutiny of the original survey exposures as for MASH but were relatively straightforward to uncover from the digital images via application of semi-automated discovery techniques. We suspect the few PNe still hidden in the H$\alpha$ survey will lie outside our search criteria or be difficult to find.

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## An Expanding Shell and Synchrotron Jet in RS Ophiuchi

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We report high-resolution radio imaging of the recurrent nova RS Ophiuchi (RS Oph) during the first month of the 2006 outburst, using the Very Long Baseline Array (VLBA). Observations made on days 20.8 and 26.8 of the outburst show a synchrotron-emitting partial shell that is much brighter to the east than to the west. Assuming the broad component of the infrared lines corresponds to the outermost part of the shell seen by the VLBA, the distance to the source is $2.45 \pm 0.4$ kpc. The circular shape and spectral indices of the shell emission challenge simple models for the radio structure immediately after the outburst. The second epoch also shows an additional, resolved, synchrotron-emitting component well to the east of the shell. Its inferred velocity is comparable to the escape speed from the surface of a high-mass white dwarf. This component was not seen in the first epoch. Its appearance may be related to the outflow reaching the edge of the nebula created by the red giant wind, which had been re-filling the void left by the last outburst in 1985. This eastern component is likely related to the jets previously seen in this and other symbiotic stars, and represents the earliest clear detection of such a jet, as well as the best case yet for synchrotron emission from a white dwarf jet.

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## The pulsation modes of the pre-white dwarf PG 1159–035

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PG 1159–035, a pre-white dwarf with $T_{\rm eff} = 140,000$ K, is the prototype of both two classes: the PG 1159 spectroscopic

class and the DOV pulsating class. Previous studies of PG 1159–035 photometric data obtained with the Whole Earth Telescope (WET) showed a rich frequency spectrum allowing the identification of 122 pulsation modes. In this work, we used all available WET photometric data from 1983, 1985, 1989, 1993 and 2002 to identify the pulsation periods and identified 76 additional pulsation modes, increasing to 198 the number of known pulsation modes in PG 1159–035, the largest number of modes detected in any star besides the Sun. From the period spacing we estimated a mass $M = 0.59 \pm 0.02$ M$_\odot$ for PG 1159–035, with the uncertainty dominated by the models, not the observation. Deviations in the regular period spacing suggest that some of the pulsation modes are trapped, even though the star is a pre-white dwarf and the gravitational settling is ongoing. The position of the transition zone that causes the mode trapping was calculated at $r_c = 0.83 \pm 0.05$ stellar radius. From the multiplet splitting, we calculated the rotational period $P_{rot} = 1.3920 \pm 0.0008$ days and an upper limit for the magnetic field, $B < 2000$ G. The total power of the pulsation modes at the stellar surface changed less than 30% for $l = 1$ modes and less than 50% for $l = 2$ modes. We find no evidence of linear combinations between the 198 pulsation mode frequencies. PG 1159–035 models have not significative convection zones, supporting the hypothesis that nonlinearity arises in the convection zones in cooler pulsating white dwarf stars.

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# Evolution of massive AGB stars : II model properties at non-solar metallicity and the fate of SAGB stars

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Massive AGB (hereafter super-AGB or SAGB) stars ignite carbon off-center and have initial masses ranging between $M_{up}$, the minimum initial mass for carbon ignition, and $M_{mas}$ the minimum mass for the formation of an iron core collapse supernova. In this mass interval, stars more massive than $M_n$ will undergo an electron capture supernova (EC-SN).
We study the fate and selected evolutionary properties of SAGB stars up to the end of the carbon burning phase as a function of metallicity and core overshooting.
The method is based on the analysis of a large set of stellar models covering the mass range 5–13 $M_\odot$ and calculated for 7 different metallicities between $Z = 10^{-5}$ and twice solar. Core overshooting was considered in two subsets for $Z = 10^{-4}$ and 0.02. The models are available on line at http://www-astro.ulb.ac.be/∼siess/database.html. The fate of SAGB stars is investigated through a parametric model which allows us to assess the role of mass loss and of the third dredge-up.
Our main results can be summarized as follows: *a*) prior to C-burning, the evolution of SAGB stars is very similar to that of intermediate-mass stars, being more luminous, *b*) SAGB stars suffer a large He enrichment at the end of the second dredge-up, *c*) the limiting masses $M_{up}$, $M_n$ and $M_{mas}$ present a nonlinear behavior with $Z$, characterized by a minimum around $Z = 10^{-4}$, *d*) the values of $M_{up}$, $M_n$ and $M_{mas}$ are decreased by $\sim 2$ M$_\odot$ when core overshooting is considered, *e*) our models predict a minimum oxygen-neon white dwarf mass of $\sim 1.05$ M$_\odot$, *f*) the determination of $M_n$ is highly dependent on the mass loss and core growth rates, *g*) the evolutionary channel for EC-SN is limited to a very narrow mass range of $\lesssim 1 - 1.5$ M$_\odot$ width and this mass window can be further decreased if some metallicity scaling factor is applied to the mass loss rate, *h*) the final fate of SAGB stars is connected to the second dredge-up and this property allowed us to refine the initial mass range for the formation of EC-SN. We find that if the ratio of the mass loss rate to the core growth rate averaged over the post carbon-burning evolution $\zeta = |\dot{M}_{wind}/\dot{M}_{core}|$ is greater than about $70 - 90$, the evolutionary path to EC-SN is not accessible.

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*Available from* http://www-astro.ulb.ac.be/∼siess/database.html#SAGB

# Rare White dwarf stars with carbon atmospheres

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White dwarfs represent the endpoint of stellar evolution for stars with initial masses between approximately 0.07 $M_\odot$ and 8-10 $M_\odot$, where $M_\odot$ is the mass of the Sun (more massive stars end their life as either black holes or neutron stars). The theory of stellar evolution predicts that the majority of white dwarfs have a core made of carbon and oxygen, which itself is surrounded by a helium layer and, for ∼80 per cent of known white dwarfs, by an additional hydrogen layer. All white dwarfs therefore have been traditionally found to belong to one of two categories: those with a hydrogen-rich atmosphere (the DA spectral type) and those with a helium-rich atmosphere (the non-DAs). Here we report the discovery of several white dwarfs with atmospheres primarily composed of carbon, with little or no trace of hydrogen or helium. Our analysis shows that the atmospheric parameters found for these stars do not fit satisfactorily in any of the currently known theories of post-asymptotic giant branch evolution, although these objects might be the cooler counterpart of the unique and extensively studied PG 1159 star H 1504+65. These stars, together with H 1504+65, might accordingly form a new evolutionary sequence that follow the asymptotic giant branch.

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# Optical line profiles of the Helix planetary nebula (NGC 7293) to large radii

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New, very long (25′), cuts of spatially resolved profiles of the H$\alpha$ and [N II] optical emission lines have been obtained over the face of the Helix nebula, NGC 7293. These directions were chosen to supplement previous similar, though shorter, cuts as well as crossing interesting phenomena in this nebular envelope. In particular, one new cut crosses the extremes of the proposed CO $J = 2 - 1$ emitting outer 'torus' shown by Huggins and his co-workers to be nearly orthogonal to its inner counterpart. The second new cut crosses the extensive outer filamentary arcs on either side of the bright nebular core. It is shown that NGC 7293 is composed of multiple bipolar outflows along different axes. Hubble-type outflows over a dynamical timescale of 11,000 yr are shown to be occurring for all the phenomena from the smallest He II emitting core out to the largest outer filamentary structure. All must then have been ejected over a short time scale but with a range of ejection velocities.

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# Merged ionization/dissociation fronts in planetary nebulae

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The hydrogen ionization and dissociation front around an ultraviolet radiation source should merge when the ratio of

ionizing photon flux to gas density is sufficiently low and the spectrum is sufficiently hard. This regime is particularly relevant to the molecular knots that are commonly found in evolved planetary nebulae, such as the Helix Nebula, where traditional models of photodissociation regions have proved unable to explain the high observed luminosity in $H_2$ lines. In this paper we present results for the structure and steady-state dynamics of such advection-dominated merged fronts, calculated using the Cloudy plasma/molecular physics code. We find that the principal destruction processes for $H_2$ are photoionization by extreme ultraviolet radiation and charge exchange reactions with protons, both of which form $H_2^+$, which rapidly combines with free electrons to undergo dissociative recombination. Advection moves the dissociation front to lower column densities than in the static case, which vastly increases the heating in the partially molecular gas due to photoionization of $He^0$, $H_2$, and $H^0$. This causes a significant fraction of the incident bolometric flux to be re-radiated as thermally excited infrared $H_2$ lines, with the lower excitation pure rotational lines arising in 1000 K gas and higher excitation $H_2$ lines arising in 2000 K gas, as is required to explain the $H_2$ spectrum of the Helix cometary knots.

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## A peculiar planetary nebula candidate in a globular cluster in the Fornax dwarf spheroidal galaxy

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Until now, only one planetary nebula (PN) was known in the Fornax dwarf spheroidal galaxy. I report the discovery of a second PN candidate, associated with one of the 5 globular clusters (GCs) in the Fornax dwarf. Spectra of the GC, obtained with the UVES echelle spectrograph on the ESO Very Large Telescope, show [O III] line emission at a radial velocity consistent with membership of the Fornax dwarf. A possible counterpart of the [O III] emission is identified in archival images from the Wide Field Planetary Camera 2 on board the Hubble Space Telescope. The source of the emission is located about 1.5″ (less than one core radius) southwest of the centre of the cluster and is identified as a likely PN, albeit with several peculiar properties. No H$\beta$, He I, or He II line emission is detected and the [O III]/H$\beta$ ratio is $> 25$ ($2\ \sigma$). The expansion velocity inferred from the [O III] 5007 Å line is about 55 km s$^{-1}$, which is large for a PN. The diameter measured on the HST images is about 0.23″ or 0.15 pc at the distance of the Fornax dSph. This object doubles the number of known PNe in Fornax, and is only the 5$^{\rm th}$ PN associated with an old GC for which direct imaging is available. It may be a member of the rare class of extremely H-deficient PNe, the second such case found in a GC.

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## Hubble-type outflows of the high-excitation, poly-polar planetary nebula NGC 6302 — from expansion proper motions.

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The outflowing proper motions of fifteen knots in the dominant northwestern lobe of the high-excitation poly-polar planetary nebula NGC 6302 have been determined by comparing their positions relative to those of faint stars in an image of the San Pedro Mártir Observatory in 2007 to those in a South African Astronomical Observatory archival plate obtained by Evans in 1956. The Hubble-type expansion of this lobe is now directly confirmed in a model independent way from these measurements. Furthermore, an unambiguous distance to NGC 6302 of $1.17 \pm 0.14$ kpc is

now determined. Also all the velocity vectors of the fifteen knots (and two others) point back to the central source. An eruptive event from within the central torus, approximately 2200 years previously must have created the high speed lobes of NGC 6302.

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## The enigma of GCIRS 3 — Constraining the properties of the mid-infrared reference star of the central parsec of the Milky Way with optical long baseline interferometry.

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Context: GCIRS 3 is the most prominent MIR-source in the central parsec of the Galaxy. NIR spectroscopy failed to solve the enigma of its nature. The properties and peculiarities of extreme individual objects of the central stellar cluster contribute to our knowledge of star and dust formation close to a supermassive black hole.
Aims: We initiated an unprecedented interferometric experiment to understand the nature of GCIRS 3 and investigate its properties as spectroscopic and interferometric reference star at 10 $\mu$m.
Methods: VLT/VISIR imaging separates a compact source from diffuse, surrounding emission. The VLTI/MIDI instrument was used to measure spectroscopically resolved visibility moduli at an angular resolution of $\sim$10 mas of that compact 10 $\mu$m source, still unresolved by a single VLT. Recent NIR/MIR photometry data were added to enable simple SED- and full radiative transfer-modeling of the data.
Results: The luminosity and size estimates show that IRS 3 is probably a cool carbon star enshrouded by a complex dust distribution. Blackbody temperatures were derived. The coinciding interpretation of single telescope and interferometric data confirm dust emission from several different spatial scales. The interferometric data resolve the inner rim of dust formation. Despite observed deep silicate absorption towards GCIRS 3 we favor a carbon rich circumstellar dust shell. The silicate absorption most probably takes place in the outer diffuse dust, which is mostly ignored by MIDI measurements, but well observable in complementary VLT/VISIR data. This indicates physically and chemically distinct conditions of the local dust, changing with the distance to GCIRS 3.
Conclusions: We have demonstrated that optical long baseline interferometry at infrared wavelengths is an indispensable tool to investigate sources at the Galactic Center. Our findings suggest further studies of the composition of interstellar dust and the shape of the 10 $\mu$m silicate feature at this outstanding region.

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## X-ray emission from jet-wind interaction in planetary nebulae

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We conduct 2D numerical simulations of jets expanding into the slow wind of asymptotic giant branch stars. We show that the post-shock jets' material can explain the observed extended X-ray emission from some planetary nebulae (PNs). Such jets are thought to shape many PNs, and therefore it is expected that this process will contribute to the X-ray emission from some PNs. In other PNs (not simulated in this work) the source of the extended X-ray emission is the shocked spherical wind blown by the central star. In a small fraction of PNs both sources might contribute, and

a two-temperatures gas will fit better the X-ray properties than a one-temperature gas. A spacial separation between these two components is expected.

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## The link between chemical anomalies along the red giant branch and the horizontal branch extension in globular clusters

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We find a strong correlation between the extension of the Na-O anticorrelation observed in red giant branch (RGB) stars and the high temperature extension of the horizontal branch (HB) blue tails of Galactic globular clusters (GCs). The longer is the O-depleted tail of the Na-O anticorrelation observed in the RGB stars, the higher is the maximum temperature reached by the bluest HB stars in the GC. This result provides a clear, empirical evidence of a link between the extension of the HB and the presence of star-to-star abundance variations of proton-capture elements in GC stars. We discuss the possible interpretation of this correlation.

**Accepted for publication in Astrophysical Journal Letters**
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# *Conference Papers*

## KPD 0005+5106: Hottest DO White Dwarf Much Hotter Than Assumed

*K. Werner*[1], *T. Rauch*[1] *and J.W. Kruk*[2]

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KPD 0005+5106 is the hottest known helium-rich white dwarf. We have identified Ne VIII lines in UV and optical spectra and conclude that it is significantly hotter than previously thought, namely $T_{\rm eff} = 200,000$ K instead of 120,000 K. This is a possible explanation for the observed hard X-ray emission as being of photospheric origin. Concerning its evolutionary state, we suggest that KPD 0005+5106 is not a descendant of a PG 1159 star but more probably related to the O(He) stars and RCrB stars.

**Poster contribution, published in Hydrogen-deficient stars, Tübingen Sept. 2007, eds. K. Werner & T. Rauch, ASP Conf.Ser.**
*Available from* arXiv:0710.4515
*and from* http://astro.uni-tuebingen.de/publications/paper_07_16b.shtml

# Elemental Abundances in PG 1159 Stars

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The hydrogen-deficiency in extremely hot post-AGB stars of spectral class PG 1159 is probably caused by a (very) late helium-shell flash or a AGB final thermal pulse that consumes the hydrogen envelope, exposing the usually-hidden intershell region. Thus, the photospheric elemental abundances of these stars allow to draw conclusions about details of nuclear burning and mixing processes in the precursor AGB stars. We compare predicted elemental abundances to those determined by quantitative spectral analyses performed with advanced non-LTE model atmospheres. A good qualitative and quantitative agreement is found for many species (He, C, N, O, Ne, F, Si, Ar) but discrepancies for others (P, S, Fe) point at shortcomings in stellar evolution models for AGB stars. PG 1159 stars appear to be the direct progeny of [WC] stars.

**Oral contribution, published in Hydrogen-deficient Stars, Tübingen, Sept. 2007, eds. K. Werner & T. Rauch, ASP Conf.Ser.**
*Available from* arXiv:0710.4506
*and from* http://astro.uni-tuebingen.de/publications/paper_07_16a.shtml

# A principal component analysis approach to the morphology of Planetary Nebulae

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Principal Component Analysis (PCA) is a well-known technique used to decorrelate a set of vectors. It has been applied to explore the star formation history of galaxies or to determine distances of mass-lossing stars. Here we apply PCA to the optical data of Planetary Nebulae (PNe) with the aim of extracting information about their morphological differences. Preliminary analysis of a sample of 55 PNe with known abundances and morphology shows that the second component (PC2), which results from a relation produced by the parameters log(N/O), initial and final mass of PNe, is depending on the morphology of PNe. It has been found that when $\log(\mathrm{N/O}) < -0.18$ the PNe's nitrogen is low independently on the oxygen abundance for either Bipolar ($B$), Elliptical ($E$) or Round ($R$) PNe. An interesting result is that both $E$ and $R$ PNe have $\log(\mathrm{N/O}) < 0$ while only $B$ PNe show negative and positive values. Consequently, $B$ PNe are expected to have higher nitrogen values than the $E$ and $R$ PNe. Following that and a second sample of 35 PNe, $n_e$ is also found to be higher in $B$ PNe. Also, in all PNe morphologies PC2 appears to have a minimum at 0.89 and PNe's initial mass at 2.6 $M_\odot$. 5-D diagrams between PCAs components and physical parameters are also presented. More results will follow while simple models will be applied in order to try to give a physical meaning to the components.

**Poster contribution, published in "Asymmetric Planetary Nebulae IV", eds. R.L.M. Corradi, A. Manchado & N. Soker, La Palma (Spain), July 2007**
*Available from* arXiv:0710.4019

# Nuclear burning and mixing in the first stars: entrainment at a convective boundary using the PPB advection scheme

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The evolution of the first generations of stars at zero or extremely low metallicity, and especially some crucial properties

like the primary $^{14}$N production, is charactarized by convective-reactive mixing events that are mostly absent from similar evolution phases at solar-like metallicity. These episodes occur when unprocessed H-rich material is mixed accross a convective boundary into $^{12}$C rich He-burning material, as for example in He-shell flashes of extremely-low metallicity AGB stars. In this paper we describe the astrophysical context of such convective-reactive events, including the difficulty of current one-dimensional stellar evolution models to correctly simulate these evolutionary phases. We then describe the requirements and current state of modeling convective-reactive processes in the first stars environment. We demonstrate some of the new concepts that we are applying to this problem, i.e. the highly accurate PPB advection scheme in the framework of PPM hydrodynamic simulations of mixing accross a very stiff convective boundary. We show initial results of such simulations that address the first non-reactive step of this problem, which is the entrainment of H at the top boundary of the He-shell flash convection zone.

**Oral contribution, published in First Stars III, Santa Fe, 2006**
*Available from* arXiv:0711.2091

# The Formation of Hydrogen Deficient Stars through Common Envelope Evolution

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We present preliminary results from Smooth Particle Hydrodynamics (SPH) simulations of common envelope evolution. We qualitatively compare the interaction between a 0.9 $M_\odot$ red giant with two different companion masses: a 0.05 $M_\odot$ brown dwarf and a 0.25 $M_\odot$ white dwarf companion.

**Oral contribution, published in "Hydrogen Deficient Stars" (Tübingen 2007)**
*Available from* arXiv:0711.0322

# The chemical imprint of super-AGB stars

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The evolution and nucleosynthesis of stars in the mass range $\sim 7-11$ $M_\odot$ is reviewed. The main evolutionary features can be summarized as follows : off-center carbon ignition followed by the propagation of a flame to the center, formation of a neon-oxygen core and subsequent development of recurrent instabilities in the helium burning shell during the so-called thermally pulsing super-AGB (SAGB) phase. Our analysis of the pulse properties and nucleosynthesis show that owing to large dilution factors, the surface modifications induced by third dredge-up episodes are weak. The chemical imprint of SAGB stars mainly results from the action of hot bottom burning, namely a large production of $^{13}$C, $^{14}$N, $^{25}$Mg, $^{26}$Al and potentially of $^{23}$Na. We also briefly describe how the mass range where SAGB stars lie depends on the metallicity.

**Oral contribution, published in Why Galaxies Care About AGB Stars**
*Available from* http://www-astro.ulb.ac.be/∼siess/news.html

## Mass loss and supernova progenitors

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We first discuss the mass range of type IIP SN progenitors and how the upper and lower limits impose interesting constraints on stellar evolution. Then we discuss the possible implications of two SNe, 2002ap and 2006jc, for Wolf-Rayet star mass-loss rates and long Gamma-ray bursts.

**Oral contribution, published in Unresolved Problems in Stellar Astrophysics**
*Available from* arXiv:0711.2630

## Hot DQ White Dwarf Stars: A New Challenge to Stellar Evolution

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We report the discovery of a new class of hydrogen-deficient stars: white dwarfs with an atmosphere primarily composed of carbon, with little or no trace of hydrogen or helium. Our analysis shows that the atmospheric parameters found for these stars do not fit satisfactorily in any of the currently known theories of post-asymptotic giant branch (AGB) evolution, although these objects might be the cooler counter-part of the unique and extensively studied PG 1159 star H 1504+65. These stars, together with H 1504+65, might thus form a new evolutionary post-AGB sequence.

**Oral contribution, published in "Hydrogen-Deficient Stars", held in Tübingen, Germany, Sept. 17-21 (2007)**
*Available from* arXiv:0711.3458

## High energy X-ray emission from recurrent novae in quiescence: T CrB

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We present Suzaku X-ray observations of the recurrent nova T CrB in quiescence. T CrB is the first recurrent nova to be detected in the hard-X-ray band ($E \sim 40.0$ keV) during quiescence. The X-ray spectrum is consistent with cooling-flow emission emanating from an optically thin region in the boundary layer of an accretion disk around the white dwarf. The detection of strong stochastic flux variations in the light curve supports the interpretation of the hard X-ray emission as emanating from a boundary layer.

**Oral contribution, published in RS Oph (2006)**
*Available from* arXiv:0711.0725

## Modeling He-rich subdwarfs through the Hot-Flasher scenario: First Results

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We present first results from evolutionary simulations aimed at exploring the Hot-Flasher scenario for the formation of H-deficient subdwarf stars. The two types of late hot flashers that lead to He-enriched surfaces, "deep" and "shallow" mixing cases, are investigated for different metallicities.

**Poster contribution, published in Third Conference on Hydrogen Deficient Stars, Tübingen, September, 2007**
*Available from* arXiv:0711.0140

## The importance of the remnant's mass for VLTP born again times. Implications for V4334 Sgr and V605 Aql

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We present numerical simulations of the very late thermal pulse (VLTP) scenario for a wide range of remnant masses. We show that, by taking into account the different possible remnant masses, the fast outburst evolution of V4334 Sgr (a.k.a. Sakurai's Object) and V605 Aql can be reproduced within standard 1D stellar evolution models. A dichotomy in the born again timescales is found, with lower mass remnants evolving in a few years and higher mass remnants ($M \gtrsim 0.6\ M_\odot$) failing to expand due to the H-flash and, as a consequence, evolving in timescales typical of He-shell flash driven born agains ($\sim 100$ yr).

**Oral contribution, published in Third Conference in Hydrogen Deficient Stars**
*Available from* arXiv:0711.4565

# *Thesis*

## Stellar populations and dust formation in the inner galaxy

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In this thesis, we study several aspects related to the final stages of stellar evolution of low-mass stars. Medium resolution near-IR spectra of OH/IR stars in the Galactic Centre (GC) are analysed with respect to the water content and the equivalent-line widths of Na, Ca, and CO(2,0) lines. The latter lines can be used to obtain an estimate of the metallicity. We showed that this method is not applicable for the OH/IR stars because of the water content, the high mass-loss rate, and the variability of the stars. Based on a sample of AGB stars in the Galactic Bulge (GB), we studied the dust composition around oxygen-rich AGB stars in function of the age on the AGB and compared this to the theoretical oxygen-rich dust condensation sequence. Although we see some trend between the dust composition and the mass-loss rate, there is no clear one-to-one relation. Especially the lowest mass-loss rate stars show a larger spread in dust composition. If the objects are studied in function of there variability in a $(\log P, K_0)$ diagram, the trend seen in the dust spectra becomes more clear. Based on the analysis of near-IR spectra, it became clear that the

dust composition, especially a large amount of alumina-rich dust, is correlated with a larger equivalent-line width of Na, which is related to the metallicity. The kind of dust formed around oxygen-rich AGB stars, is therefore not only related to the mass-loss rate. In a last chapter we trace the stellar content in, and the geometry of the Galactic Bulge. Using the galaxymodel TRILEGAL, we analysed 2MASS and OGLE-II observations of 11 OGLE-II fields in the GB. Based on the comparison between model and observations, we found that the distance to the GC is $8.6^{+0.15}_{-0.11}$ kpc and the angle between the bar and the Sun-Centre line is $14.4^{+5.5}_{-10.3}$ deg. Concerning the star formation rate, we obtained the best results using a starburst 10 Gyr ago and no young and/or intermediate age population could be deteced using this method.

**Defended on November the $14^{\text{th}}$ 2007 at the University of Leuven.**
*Available from* http://www.ster.kuleuven.be/pub/vanhollebeke_phd/

# *Job Advert*

## Cornell University, USA
## Post-doctoral fellow on IRS team

The Spitzer Infrared (IRS) Group at Cornell University invites applications for a Postdoctoral Research position with the IRS Team (PI Jim Houck). Information on the Spitzer Space Telescope and the IRS can be found at:

http://ssc.spitzer.caltech.edu and
http://isc.astro.cornell.edu/

The successful applicant will study dust formation and evolution in Local Group galaxies and help support the IRS Team's ongoing programs. They will have access to all data obtained as part of the Team's Guaranteed Time Observations on the Spitzer Space Telescope. The primary responsibilities will be the analysis and interpretation of spectra of evolved stars, circumstellar material, and interstellar material in the Galaxy, Large Magellanic Cloud, Small Magellanic Cloud, and other Local Group galaxies.

We are interested in innovative individuals with some background in infrared astronomy and/or spectroscopy, who work well on group activities and have the desire to contribute to the scientific end products. A Ph.D. in astronomy, physics, or a closely related field is required. The appointment will initially be for two years, contingent upon on available funding. Competitive salary will depend on experience.

To apply, please send a copy of your vita, research interests and the names of three individuals who are willing to write reference letters to Ms. Laurie McCall, Cornell University, 228 Space Sciences Building, Ithaca, NY 14853. Applications via email to lm19@cornell.edu are encouraged. For full consideration, applications should be received by December 15, 2007. However, applications will be accepted until the position is filled. Cornell University is an Equal Opportunity/Affirmative Action Employer.

*See also* http://isc.astro.cornell.edu/twiki/bin/view/Main/IrsJobs

# Astronomical Polarimetry 2008

Astronomical Polarimetry 2008
Science from Small to Large Telescopes
6-11 July 2008
Fairmont Le Manoir Richelieu, La Malbaie
Québec, Canada
First Announcement

Dear Colleague,

We are pleased to announce the convening of a Conference on uv - optical - infrared - mm/submm (OIM) Astronomical Polarimetry, in the wonderful Charlevoix region by the St-Lawrence River in July 2008. It is located about 400 km (4 1/2 hours drive) from Montreal, and 150 km (2 hours drive) from the Québec airport.

The aim of the Conference is to bring together workers in all areas of OIM astronomical polarimetry to discuss the most recent results in this exciting and crucial field, and to consider the potential for polarimetry with telescopes of all sizes. The meeting will concentrate on ground-based polarization measurements, and will include a session devoted to new and novel instrumentation. The remaining sessions will be organized according to the astronomical source rather than to wavelength regime or specific technique. Neither Radio polarimetry nor Solar polarimetry are within the conference remit, but each will be the subject of review talks which will set the scene for two of the conference sessions.

If you are interested in attending this meeting, please let us know. Note that registration pages on the conference web site will open for business around 7-Jan-2008. Emails sent to the conference address (given at the bottom of this note) will give a useful indication of the likely interest. Space may be limited, so we would strongly encourage you to do this at this point.

Science Areas

Sessions will be divided into two, with approximately 80% of the time guaranteed for current results and 20% for presentations on future directions, facilities etc. Proceedings, including posters, will be published. Details of the division between oral and poster presentations will be given in the second announcement. The following science areas will be covered:

Techniques and Instrumentation
Theory and Modelling
Solar system
Interstellar Dust and Gas
Star Formation
Circumstellar Disks and Extrasolar Planets
Stars and Stellar Magnetism
Galaxies, Radio Galaxies and AGN
High-redshift and Cosmological Polarimetry

Dates and Deadlines

Second Announcement and Web site opens for registration: 7-Jan-2008
Commencement of Registration: 7-Jan-2008
Third Announcement: 1-Apr-2008
End of Early Registration: 23-May-2008

Abstract Deadline: 1-May-2008
Late Registration Deadline: 6-June-2008

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Conference web site: www.astro.umontreal.ca/astropol2008
Contact email address: pol2008@astro.umontreal.ca

*See also* http://www.astro.umontreal.ca/astropol2008