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From the editors

Dear readers of the ex-AGB Newsletter,

We have got some trouble with the title of our publication. We have just received a complaint from the Antropo-Geo-Biology Society, informing us that this Society edits a centenary publication, also named AGB Newsletter. They fear that some of the Antropo-Geo-Biology Society members could mingle both publications and conclude that their Society has decided, against their will, to switch over to electronic publication. Accordindly, they kindly request that we abandon this title.

Rather than delaying the april issue we have preferred to publish it with an "anonymous" title, and we require your help to find a new name by the end of the month.

Claudine Kahane and Thierry Forveille

Abstracts of recently accepted papers

A model for the space density of dwarf carbon stars

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Recent studies of faint high latitude carbon stars have shown that a significant fraction of them are not distant AGB stars, but rather belong to the local population of spheroid dwarfs. In this paper we attempt a theoretical prediction of the local space density of such dwarf carbon (dC) stars, based on the assumption that they are ordinary main sequence stars that were able to accrete enough carbon-enriched material from a binary companion on the AGB to make their C/O ratio larger than unity.

A simulated population of dCs is constructed by following the evolution of a large number of binaries using simple analytic fits to detailed evolutionary calculations, and determining which ones would presently contain a dC star. The zero-age parameters of the sample are chosen randomly from distributions derived from the observed properties of unevolved binaries.

The space density of halo dC stars that we predict ($\sim 2-4 \times 10^{-7}\ pc^{-3}$) is in agreement with current observational constraints. The predicted local space density of disk dC stars ($\sim 1 \times 10^{-6}\ pc^{-3}$) may be somewhat

higher than observed. The fraction of binaries that produces dCs depends strongly on initial metallicity, and virtually no dCs are formed in systems with an initial metallicity of more than half solar. Thus all disk dCs are predicted to be in binaries that formed in the very early phases of disk star formation, and their number depends strongly on assumptions about the age-metallicity relation during this epoch. The predictions for the halo are much less model-dependent.

The simulated orbital period distributions are bimodal, with one peak between 10^3 and 10^5 days and another peak between 10^2 and 10^3 days. The shorter-period component is caused by systems that have gone through a common envelope phase. The simulated period distributions bear a strong resemblance to the observed orbital period distribution of barium and CH giants, which may be the evolved descendants of the disk and halo dC populations we have modeled.

Accepted by Astrophys.J. *For preprints, contact dekool@mpa-garching.mpg.de*

Pulsating Cool Stars and Galactic Structure

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The review concerns the use of Miras and OH/IR stars as probes of Galactic structure and concentrates on groups of stars with both kinematic and luminosity data. The reliability of distance determinations for these stars is covered in some depth. Kinematic and scale height data for local Miras suggest that those with pulsation periods of around 200 day are members of the thick disk or inner halo. Longer-period stars are kinematically cooler and have smaller scale heights. Stars with moderate dust shells, which may be more evolved, seem to belong to the same population as thin-shelled sources with the same pulsation period. Our current knowledge of the structure of the Galactic Bulge is reviewed, as is our understanding of its rotation as derived from observations of SiO Masers from Mira variables. Infrared and radio surveys, in progress or planned, offer us the potential to extend the study of low-mass metal-rich stars well beyond the solar neighbourhood.

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For preprints, contact paw@saao.ac.za

New kinematic distances of NGC 7009 and BD+30^{o}3639 from UV and radio data

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Measurements of the equivalent width of the interstellar Lyman α line from IUE in the direction of the planetary nebulae NGC 7009 and BD+30^{o}3639 are used to infer the H column density in these directions. Hydrogen 21 cm profiles are also used in connection with the ultraviolet data so that the expected rotation velocities and distances can be determined. The results are compared with recently published distances, in an attempt to distinguish between the “short” and “long” PN distance scales as applied to these objects.

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The rich O II recombination spectrum of NGC 7009: new observations and atomic data

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We have constructed fully self-consistent, detailed photoionization models for two planetary nebulae (PN) in the Small Magellanic Cloud (SMC), namely SMC N 2 and SMC N 5, to fit optical and UV spectrophotometric observations as well as HST Faint Object Camera (FOC) narrow band images taken in the light of Hβ. The derived density structure shows that both PN have a central cavity surrounded by a shell of decreasing density described by a parabolic curve. For both nebulae, our models fail to reproduce the HST images taken in the light of the [O III] λ5007 line, in the sense that the observed [O III] λ5007 surface brightness decreases more slowly outside the peak emission than predicted. An effective temperature of $T_{eff} = 111500$ K, a stellar surface gravity of $log\, g = 5.45$ and a luminosity of $L_* = 8430\, L_\odot$ are derived for the central star of SMC N 2; similarly $T_{eff} = 137500$ K, $log\, g = 6.0$ and $L_* = 5850\, L_\odot$ are derived for SMC N 5. SMC N 2 is optically thin and has a total nebular mass (H plus He) of 0.180 $M_\odot$, while SMC N 5 is optically thick and has an ionized gas mass of 0.194 $M_\odot$. Using the H-burning SMC metal abundance ($Z = 0.004$) evolutionary tracks calculated by Vassiliadis & Wood (1994), core masses of 0.674 $M_\odot$ and 0.649 $M_\odot$ are derived for SMC N 2 and SMC N 5, respectively. Similarly, from the He-burning evolutionary tracks of Vassiliadis & Wood for progenitor stars of mean LMC heavy element abundance ($Z = 0.008$), we find $M_c = 0.695$ and 0.675 $M_\odot$ for SMC N 2 and SMC N 5, respectively. We find that Hβ images are needed if one is to derive accurate stellar luminosities directly from photoionization modelling. However, in the absence of a Hβ image, photoionization models based on [O III] images (and nebular line intensities) yield accurate values of T_{eff} and $log\, g$, which in turn allow reliable stellar masses and luminosities to be derived from a comparison with theoretical evolutionary tracks. We show that the correct nebular ionized mass can be deduced from the nebular Hβ flux provided the mean nebular density given by the C III] λ1909/λ1907 ratio is also known.

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Mass-losing Stars in the South Galactic Cap

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Observations are presented for 162 late-type stars in the South Galactic Cap ($b < -30^o$) which were selected on the basis of their IRAS 25/12 μm flux ratios as high-mass-loss candidates. JHKL photometry (over 1100 observations) was obtained for all of the stars, BV$(RI)_C$ photometry for 78 of them and optical spectra for 51. 154 of these stars are non-Mira M or S stars, of which many, and possibly all, are semi-regular variables. Of the remaining 8 IRAS objects, three are T Tauri stars, three are interacting binaries and two are carbon stars.

A few of the M giants and both of the carbon stars have circumstellar envelopes of the type more normally associated with Mira variables. These include two 1612 MHz OH-Maser sources. It is suggested that such stars may have been Miras in the recent past, but are currently out of the instability strip owing to a recently experienced helium-shell flash. Alternatively some of them could be binary stars, but there is as yet no evidence for the second star.

The near-infrared colours of the M giants are compared with those of similar stars in the Bulge. They are similar to those of the inner Bulge and unlike those found in either the outer Bulge or the globular clusters. The kinematics and galactic distribution of the M giants indicate that they are probably from a mixed population and that they could be associated with Miras with a range of periods. A comparison of the observed colours

with those derived from models indicates a range of metallicity with the bulk of stars slightly more metal rich than the sun. It also reveals significant numbers of stars with colours outside the predicted range, possible due to the effects of circumstellar reddening or to inadequacies in the models. The most metal-rich examples of the M-stars have high mass-loss rates for non-Miras ($\sim 10^{-6} M_{\odot} yr^{-1}$) and there are far fewer of them outside than inside the solar circle. This may be due to a metallicity gradient. These stars have a scale height of more than 500pc.

The two carbon stars have unusual colours and detached shells. One of them, R Scl, is shown to vary with a period of 379 day superimposed on a possible second period of about 2300 days. The other carbon star, which is more distant and previously unknown, may also have double period variations.

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For preprints, contact paw@saao.ac.za

Investigating the Near-Infrared Properties of Planetary Nebulae. I. Narrowband Images

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We present the results of a near-infrared narrowband imaging survey for a moderately sized sample of planetary nebulae. Objects were selected in a way that complements similar surveys done at visible and near-infrared wavelengths. Observations were made primarily at wavelengths of the H_2 $v = 1 \rightarrow 0$ S(1) line, hydrogen Brγ, and nearby continuum. No new detections of molecular hydrogen emission were made. The H_2 is frequently found to be extended, except in young, visibly compact objects. Our results are consistent with the already determined correlation of H_2 emission with planetary nebula morphological type. Filamentary and other kinds of structures are clearly resolved in many nebulae.

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For preprints, contact latter@dusty.arc.nasa.gov

Evolutionary Tests of the Planetary Nebula Luminosity Function

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The Planetary Nebula Luminosity Function (PNLF) depends on the physical characteristics and evolutionary paths of the components. Changes in the nebular and stellar parameters may influence the extragalactic distance scale based on PNLF. We aim at studying from a theoretical viewpoint how changes in the physical conditions of the parent galaxy and the evolutionary paths of the central stars and nebulae propagate into the PNLF. By means of synthesis of post–Asymptotic Giant Branch evolution we have tested the invariance of the distance scale based on Hβ PNLF for changes in the evolutionary time scales, in the initial mass–final mass relation, and in the number of optically thick PNs populating the PNLF. We start with a theoretical Hβ PNLF truncated at $M_f < 0.7$ $M_{\odot}$, which we successfully check against its empirical homologous for SMC and LMC PNs. We obtain that small shifts in the transition time evolve into Hβ magnitude shifts of the high luminosity cutoff up to 0.75^m for constant SFR populations only, while intermediate/old populations are almost invariant with respect to these evolutionary time differences. We also obtain that a different initial mass–final mass relation does propagate into shifts in the Hβ PNLF, the effects being important only for young stellar populations. Finally, the high luminosity cutoff of the Hβ PNLF seems to be invariant to the number of PNs considered. Overall, our results indicate that extreme care should be taken when using Hβ PNLF in the context of high mass–high luminosity PNs.

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Extreme Nitrogen Enrichment in the Asymmetrical Planetary Nebula M1–75

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In the framework of the morphological survey of northern sky planetary nebulae, in progress at the IAC, we investigate in detail those nebulae that show peculiarities, or that have not been studied before. By means of narrow–band imaging and accurate 2D spectroscopy we have analized the peculiar nebula M1–75. Its morphology is very complex, consisting of two contiguous shells, surrounded by two fainter lobes, previously undetected. With detailed plasma analysis we derive that M1–75 is a type I planetary nebula, showing extreme nitrogen enrichment in the outermost shell, making this object a good candidate for peculiar stellar evolutionary paths. The detected abundances of heavy elements are the highest ever detected in a galactic planetary nebula.

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Broad Emission Line O VI Planetary Nebulae Nuclei

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We present a study of broad–line O VI planetary nebulae nuclei (NGC 2452, NGC 5189, NGC 6905, NGC 7026, and IC 2003) in which we use the nebulae to derive the physical parameters of the central stars. From the study of the emission lines and the stellar continua we derive the effective temperatures and the luminosities of the stars, plasma characteristics and (limited) abundances. By locating the stars on the HR diagram we infer their evolutionary stages. We find that the O VI strength correlates with stellar luminosity, both for the broad–line and for the narrow–line O VI stars. By comparing observational data to theoretical results, we find good agreement between the observed pulsational periods and effective temperatures and those obtained with C–O pre–white dwarf models.

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Evidence for rapid rotation of the carbon star V Hydrae

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The carbon star V Hya is known to have a bipolar circumstellar outflow and an unusual photospheric spectrum. After measuring the changes in the photospheric velocity and carrying out a spectral broadening analysis over 10 photometric phases, we conclude that rotation due to spin-up by a companion in a common envelope configuration is the most compelling explanation for all the data taken together. After considering the spectral and velocity behavior of 74 other carbon stars, we find that V Hya is alone in our sample in having such obvious phase-dependent broadening. In this paper we detail the broadening results and explore other possible causes of spectral broadening in late type stars. In particular, we find that: 1) the spectral broadening in V Hya varies about a mean value of 13.5 km/s (with total variation of 9 km/s) in concert with the photometric phase and with a phase relationship consistent with that expected for a rapidly rotating star that conserves angular momentum as it pulsates, 2) V Hya's unusual, very long secondary period of 6500d might be attributed to a coupling of radial pulsation (529d period) with rotation, 3) the upper limit on the ultraviolet continuum flux favors a common envelope versus detached binary system, 4) the variability type, Mira versus SR variable, is uncertain since V Hya demonstrates spectral characteristics of both, and 5) the evolutionary placement on the asymptotic giant branch is in question since V Hya appears to lack ^{99}Tc, a signature element of third dredge up whose absence suggests that a mass transfer event in the past might be responsible for V Hya's carbon and s-process element enhancement.

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A search for SiO maser emission from symbiotic Miras

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A sample of 29 dusty symbiotics, mostly containing Mira primaries, has been observed in the 86GHz, v=1, J=2–1 transition of SiO, to look for maser emission. Apart from R Aqr, a known maser source, no objects were detected down to typical limits of 10^{-20}W.m^{-2}.

By comparing our results with those previously obtained on normal Miras and LPVs, we find that in symbiotics the masers are generally underluminous, or absent. By considering the possible influence of the UV radiation and tidal effects of the compact companion on the maser sites, we conclude that the likely reason for the lack of SiO maser emission from symbiotics whose orbits are not too wide is tidal disruption of the stationary or deeper layers in the Mira atmosphere. For probable wide orbit systems like RX Pup the mechanism inhibiting the SiO maser emission is still unknown.

We present and discuss a time series of maser spectra of R Aqr.

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Dissertation Abstracts

Hot Planetary Nebulae Nuclei and Related Objects

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The hottest central stars found in planetary nebulae excite the O VI atomic transition in their atmospheres. Presumably the central stars of all planetary nebulae become O VI stars during some phase of their evolution. Observational studies show that all post–asymptotic giant branch (P–AGB) stars (excluding white dwarfs) that undergo nonradial pulsations are O VI stars. A full understanding of O VI stars is therefore crucial before we can develop a complete picture of P–AGB evolution. In this thesis we study O VI central stars of planetary nebulae, with particular attention to obtaining their evolutionary paths, masses and an understanding of the physical processes of the associated nebulae. Our approach is to use analyses of nebular and stellar spectral features as diagnostics of the physical conditions that prevail in and around these objects. We obtain stellar magnitudes, Zanstra temperatures, extinction constants, abundances, and other diagnostics. By placing the central stars on the HR diagram, we estimate their masses and evolutionary timescales. Correlations between spectral characteristics and observable stellar properties suggest that narrow–line and broad–line O VI central stars belong to different mass–groups. We also calculate the nebular electron densities and distances for a larger sample of planetary nebulae and demonstrate the existence of correlations between the different density diagnostics, in substantial agreement with leading hydrodynamical models. We perform theoretical studies of instability against nonradial oscillations of hydrogen-depleted P–AGB stars and white dwarfs. Our tests of instability, which are non-adiabatic and are based on stellar surface models combined with evolutionary models, are in agreement with nonradial oscillations found from photometric measurements in O VI central stars and other hydrogen-depleted evolved stars.

From the editors

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