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From the Editors

We are very pleased to announce that the first issue of the AGB Newsletter was given a very warm welcome from the evolved stars community. With the help of the numerous suggestions of adressees that we have received, our distribution list has increased from 165 to 246 names. Unfortunately, a number of first issue sendings were returned with an error message and we solicit again your help to get the correct e-mail adresses of the colleagues listed at the end of this issue.

Many thanks to the enthousiastic contributors to this second issue of the AGB Newsletter. They testify that our field is very fruitfull (even if the actual activity is somewhat enhanced by an effect of process initialization).

Following a suggestion by some readers, back issues of the newsletter are available through anonymous ftp to gag.observ-gr.fr in directory archive/agbnews. For those of you who are familiar with xmosaic and the World Wide Web, Dennis Crabtree (crabtree@dao.nrc.ca) has made the first issue available via the URL http://cadc.dao.nrc.ca:2001/agb/agb.html. We may at some point provide a similar service on our computer.

Nota Bene : the deadline for publication in the next issue is March 25.

Claudine Kahane and Thierry Forveille

Abstracts of recently accepted papers

An Observational Estimate of the Probability of Encounters Between Mass-Losing Evolved Stars and Molecular Clouds

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One hypothesis for the elevated abundance of ^{26}Al present during the formation of the solar system is that an asymptotic giant branch (AGB) star expired within the molecular cloud (MC) containing the protosolar nebula. To test this hypothesis for star forming clouds at the present epoch, we compared nearly complete lists of rapidly mass-losing AGB stars and MCs in the solar neighborhood and identified those stars which are most likely to encounter a nearby cloud. Roughly ten stars satisfy our selection criteria. We estimated probabilities of encounter for these stars from the position of each star relative to cloud CO emission and the likely star-cloud distance along the line of sight. Typical encounter probabilities are $\sim 1\%$. The number of potential encounters and the probability for each star-cloud pair to result in an encounter suggest that within 1 kpc of the Sun, there is a $\sim$1% chance that a given cloud will be visited by a mass-losing AGB star over the next million years. This estimate is dominated by the possibility of encounters involving the stars IRC+60041 and S Cep. Over a MC lifetime, the probability for AGB encounter may be as high as $\sim$70%. We discuss the implications of these results for theories of ^{26}Al enrichment of processed and unprocessed meteoritic inclusions. If the ^{26}Al in either type of inclusion arose from AGB-MC interaction, the low probability estimated here seems to require that AGB-MC encounters trigger multiple star formation and/or that the production rate of AGB stars was higher during the epoch of solar system formation than at present. Various lines of evidence suggest only the more massive ($5 - 8$ M$_\odot$) AGB stars can produce significant ^{26}Al enrichment of star-forming clouds.

Accepted by the Astrophysical Journal (Feb. 1 issue) *For preprints, contact* jhk@juggler.mit.edu

The Bipolar Symmetry of Ring-Like Planetary Nebulae: Molecular Hydrogen Emission from Halos

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To investigate the relationship between H_2 morphology, optical halos, and the structure of planetary nebulae (PNe), we used the Cryogenic Optical Bench at Kitt Peak National Observatory to obtain deep images of representative objects in the 2.122 $v = 1 \rightarrow 0$, $S(1)$ line of H_2. We find halo H_2 emission in NGC 6720 (the Ring Nebula), in Ring-like NGC 6772 and 6781, and in bipolar NGC 2346. In general, H_2 halos precisely outline optical halos, but H_2 core to halo surface brightness ratios are much smaller than those of their optical counterparts. Shock excitation appears to be a more likely mechanism than UV excitation for producing H_2 halos in these evolved PNe. Geometric considerations then suggest that these PNe are all bipolar in structure and viewed at a range of inclination angles from nearly perpendicular to nearly pole-on.

We also present images of NGC 7027 in H_2, He I and Brγ that vividly demonstrate the spatial separation of molecular and ionized emission previously established for this PN. The detached and morphologically dissimilar H_2 and ionized emitting regions support the UV fluorescence model for this young PN.

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Detection of the λ 609 μm line of neutral atomic carbon in the Ring Nebula

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We report the detection of the 609 μm (492 GHz) ($^3P_1 - -^3P_0$) fine-structure line of neutral atomic carbon (CI) in the Ring Nebula (NGC 6720). The emission is spatially extended, and we have been able to make a preliminary strip map along the minor axis of the nebula. The peak observed emission is $\sim$500 mK, and the line width is $\sim$40 km.s$-$1, characteristic of the expanding nebula. The CI column densities at the positions where the line is detected are $4\times$ 10^{16} – 10^{17} cm^{-2}

Comparison of the CI data with high-sensitivity CO observations shows that the CI and CO emissions have roughly similar spatial distributions. The CI/CO column density ratio is >1, and may be much higher at particular positions of the nebula. The total number of CI atoms in the Ring nebula exceeds that of CO molecules by a factor of about 10. Our observations confirm that the mass of the neutral shell ($\geq$ 0.1M$_\odot$) exceeds that of the ionized nebula, and indicate that most the neutral gas probably resides in the photo-dissociation regions of rather dense ($\geq 10^5 cm^{-3}$) neutral clumps exposed to the ultraviolet radiation field of the central star.

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A Millimeter-Wavelength Survey of S Stars for Mass Loss and Chemistry

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We report the results of a survey of 27 S stars within 1 kpc of the Sun for emission from the J=1 $\rightarrow$ 0 and 2 $\rightarrow$ 1 lines of CO. For those stars with strong detections in CO, we also searched for emission from the J=1 $\rightarrow$ 0 line of HCN and the J=2 $\rightarrow$ 1, v=0 emission lines of SiO. In addition, we searched for SiO J=2 $\rightarrow$ 1, v=1 maser emission in a total of 14 stars in our sample. We derive mass loss rates for the S stars detected in CO, and compare with other estimates. Our mass loss rates from the CO J=1 $\rightarrow$ 0 line are well-correlated with the rates derived by Jura (1988) from IR flux densities and a dust model, but our values are systematically higher than Jura's by about a factor of 2. The derived gas mass loss rates for our sample are very similar to those found for carbon stars. We find, however, that the average dust/gas ratio of our sample of S stars is lower than that for carbon stars, suggesting that S stars are less efficient at producing grains, per unit of ejected mass, than are carbon stars.

Four of eight stars surveyed show definite detections of HCN in their circumstellar envelopes. Five of 7 stars have thermal (v=0) SiO emission, while 8 of 14 surveyed show maser (v=1) SiO emission. We use our results to estimate HCN and SiO abundances and compare these with the results of thermodynamic equilibrium models for the formation of these species under photospheric conditions with C/O nearly equal to unity. The HCN and SiO abundances indicate that the formation of these species must occur at temperatures low enough for grain formation to be important, which may serve to enhance production of HCN. Our results show no evidence that S stars experience a cessation of mass loss, contrary to recent suggestions.

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Is there a connection between thermal pulses and PNe halos: On the way to an answer

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We explore the hypothesis that the shells and halos of planetary nebulae (PNe) are formed during multiple phases of enhanced mass loss (superwinds). These superwinds occur on the Asymptotic Giant Branch (AGB) and are terminated by thermal pulses. Using recent results from models of AGB star evolution by Vassiliadis & Wood (1993) and published data for halos of PNe we compare the theoretical times between thermal pulses with the observed dynamical times derived from halo separations for a small but carefully selected sample of PNe. We find that the theoretical and observational time scales are within an order of magnitude from each other. Considering the large experimental errors, mainly due to uncertainties in distances, this is an encouraging result. However, a larger sample of PNe halos are needed to prove that multiple superwinds are responsible for PNe halos.

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A study of dust shells around high latitude supergiants

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A sample of 22 stars with infrared excess emission and many of which have supergiant-like spectra was surveyed in the submillimeter continuum at 438, 761 and 1100μm using the James Clerk Maxwell Telescope (JCMT, Mauna Kea, Hawaii). Most of the sources are at high galactic latitudes but stars with similar properties at lower galactic latitudes are also included.

For 16 sources it is believed that they are post Asymptotic Giant Branch stars (post-AGB stars) and 6 of them are detected. The rest of the sample consists of 2 binaries, 1 Herbig Ae star, 1 Luminous Blue Variable and 2 sources for which the post-AGB nature is uncertain.

The observations are combined with optical, near infrared and IRAS data and are fitted with a spherically symmetric and optically thin dust shell model. It is found that a large fraction of the excess emission originates from relatively hot dust near the star. Only 2 sources lack such a hot dust component.

For all stars with a hot dust component it was found that the emission longward of 60μm cannot be explained with only one dust shell. Several possible explanations are discussed and it is concluded that the extra excess at far IR and submm wavelengths is caused by a second colder and thus more distant dust component. For the post-AGB stars this component is believed to be the remnant AGB shell. The relatively low stellar temperatures ($< 10,000$ K) in combination with the relatively large ages of the remnant AGB shell ($> 10^3$ yr) confirm earlier suggestions that many of these stars are very slowly evolving towards higher temperatures, as expected for low mass post-AGB stars.

Evidence was found that stars may stop losing mass and evolve off the AGB at temperatures below 5,000 K (as assumed for the Schönberner tracks) causing a slower evolution towards higher temperatures.

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Theoretical spectra of circumstellar dust shells around carbon-rich Asymptotic Giant Branch stars

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Realistic modelling of circumstellar dust shells around evolved stars has to include a physical treatment of the interaction among hydrodynamics, thermodynamics, radiative transfer, chemistry and dust formation and -growth. A self-consistent solution of this problem is presented in the case of stationary, spherical symmetric dust-driven winds. The resulting shell structure and the mass-loss rate are completely determined by the three fundamental stellar parameters stellar mass $M_\star$, stellar luminosity $L_\star$ and effective temperature $T_{\rm eff}$ and by the element abundances $\epsilon_{\rm i}$.

A detailed calculation of the transport coefficients of the dust component by means of the particle size distribution function and the solution of the non-grey radiative transfer problem provide realistic synthetic spectra of the dust shell models.

We discuss the dependence of the resulting spectra on the stellar parameters in terms of infrared two colour diagrams. Application of these model calculations to the prominent infrared object IRC +10216 yields best agreement with the observed spectrum and the visibility data at maximum light for the stellar parameters $M_\star = 0.7 M_\odot$, $L_\star = 2.4 \cdot 10^4 L_\odot$, $T_\star = 2010$K and a carbon to oxygen ratio of $\epsilon_{\rm C}/\epsilon_{\rm O} = 1.40$, which corresponds to a mass-loss rate of $\dot{M} = 8 \cdot 10^{-5} M_\odot {\rm yr}^{-1}$. In this model only amorphous carbon grains are considered as the main opacity source.

From this model a distance to IRC +10216 of $d = 170$pc is deduced. The total mass contained in the circumstellar dust shell implies an initial main sequence mass of $M_{\rm ZAMS} \geq 1.3 M_\odot$ for IRC +10216.

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Anomalous Water Masers in OH/IR Stars

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We present OH (1612 MHz) and H_2O (22.2 GHz) maser observations made with the VLA at an angular resolution of $\sim 1''$ toward three OH/IR stars: OH12.8-0.9, OH37.1-0.8 and OH42.3-0.1. These stars exhibit the H_2O maser components in a velocity range that exceeds the OH velocity range, a situation in disagreement with the standard model for maser emission in late-type stars. We find that the OH and H_2O maser positions agree within $\sim 0\farcs5$ and that most likely both masers arise from the same source, ruling out the possibility of a fortuitous superposition of two different sources. We discuss some of the possible mechanisms that could explain the anomalous H_2O maser emission. The most likely explanation is that these stars have axisymmetric winds and that the H_2O emission originates in the polar regions and have larger velocities than the regions closer to the equator where the OH emission arises. Very long baseline observations are required to test this explanation.

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Fluorescent K I 7699 Å Emission from Circumstellar Shells of Red Giants: Evidence for Highly Asymmetric Winds

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Potassium atoms in the circumstellar shells of R Aql, V Hya, g Her, and R Leo are detected through fluorescent emission at 7699 Å at angular distances of up to several seconds of arc from the star. As traced by the 7699 Å emission, the shells are highly asymmetric.

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On the spectra and photometry of M-giant stars

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From a sample of 97 very bright M-giant stars in the solar neighbourhood, high-quality "intrinsic" spectra in the spectral range $380 \leq \lambda[\mathrm{nm}] \leq 900$ for all M-spectral subtypes of the Case and MK classification systems are obtained. The results are fitted to photospheric synthetic spectra in the range $99 \leq \lambda[\mathrm{nm}] \leq 12500$ in order to infer the corresponding continua. The synthetic spectra are also compared to the intrinsic spectra. The effective temperatures are derived and mathematical spectral classification criteria are found. The $(UB)_j(VRI)_c(JHKLM)_{ESO}$ are also given.

The data is available on the Strasbourg Astronomical Data Centre (CDS).

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Supplement to the Arecibo 1612 MHz Survey of Color Selected IRAS Sources

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The completeness of the Arecibo 1612 MHz survey of color selected IRAS sources is extended to (25-12) μm $>$ -0.7. In addition (i) most IR sources with spectral types normally associated with OH / IR stars and colors outside the coverage of the original survey have been examined; (ii) most ambiguous observations during the survey have been reobserved; (iii) most single peaked sources have been reexamined, and 17 found with second peaks. We report 39 new 1612 MHz detections, of which 34 are original. These are also surveyed in the mainlines.

Analysis of the complete flux limited survey confirms the existence of a longitude sensitivity effect in the detection of sources, which reduces the total number detected by 4 percent. This analysis sets an upper limit of 16 percent on the proportion of a color selected sample that may be identified with carbon stars and / or star formation regions.

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Synthetic AGB evolution: IV. long-period variables in the LMC

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From observations of LPVs (long period variables) in the LMC we derive that the ratio of the number of C-rich LPVs to the total number of carbon stars is ∼0.05 and that the ratio of the number of oxygen-rich LPVs to the total number of oxygen-rich AGB stars is between 0.05 and 0.10. The lifetime of the LPV phase in the LMC is only a few 10^4 yrs, considerable below estimates for the Galaxy, where the duration of the LPV phase (about 2 10^5 yrs) is similar to the total AGB lifetime. If the possible incompleteness of the surveys for LPVs is invoked to explain this discrepancy in the lifetimes then the ratio of small amplitude variables to large amplitude variables must be about 30, considerably larger than the ratio of Semi Regular to Mira variables in the Galaxy (1-3).

We present a simple model to explain the observed properties of LPVs in the LMC. It is assumed that pulsation only occurs in an instability strip in the HR-diagram. The instability strip is characterised by three parameters: the temperature at some reference luminosity, the width of the instability strip and its slope $\frac{dT_{eff}}{dM_{bol}}$. The first two are free parameters in the model. Based on observations we use $\frac{dT_{eff}}{dM_{bol}} = 275$ K mag^{-1} for $M_{\rm bol} > -5$ and 100 K mag^{-1} for $M_{\rm bol} < -5$. An additional complication is that the pulsation period depends rather sensitively on the effective temperature scale. The location of the AGB tracks in the HR-diagram (the zero point of the effective temperature scale) is the third free parameter.

Both a model with a Reimers mass loss law inside and outside the instability strip, and a model with the mass loss in the instability strip given by a scaled version of the Blöcker & Schönberner (1993) mass loss law, fit the observational constraints equally well.

We conclude that first harmonic pulsation can be excluded unless the canonical relation between (J–K) color and effective temperature (based on lunar occultation observations) gives temperatures which are too high by ∼20%, much larger than the estimated uncertainty of ∼8% or possible systematic effects (≲10%). Fundamental mode pulsation is therefore probably the dominant pulsation mode among LPVs in the LMC.

A second conclusion is that for most stars the instability strip is not the final phase of AGB evolution. Based on our calculations for individual stars we find that AGB stars more massive than about 1.2 $M_\odot$ spend a considerable amount of time in the phase between the end of pulsation and the end of the AGB. We propose an alternative explanation for (some of) the non-variable OH/IR stars in the Galaxy.

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The 3 μm spectra of candidate carbon stars

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We have searched for the 3.1 μm absorption feature, a well-known characteristic of optical carbon stars, in a sample of sixteen candidate carbon stars, most of which have very red colors and some of which have no optical counterparts. The sample was selected on the basis of similarity of LRS spectra to those of known carbon stars. We detected the 3.1 μm feature in eleven candidates, confirming them as carbon stars. There is a wide range in the strength of the feature. In general, the 3.1 μm feature weakens with redder $[K - L]$ color. However, two of the reddest stars (with $[K - L] = 5$) show the strongest features. Models of the spectrum near the 3.1

μm feature show that the absence of the 3.1 μm feature in stars with $[K-L] \gtrsim 4$ is expected, because dust emission fills in the feature, if the temperature of the dust at the inner radius is $\sim$1500 K, equal to the typical condensation temperature of carbon-rich dust. The presence of a strong 3.1 μm feature in stars with $[K-L] \approx 5$ can be explained if the dust temperature at the inner radius is $\lesssim$700 K. An alternative explanation is that in those stars there may be a circumstellar contribution to the 3.1 μm feature.

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Mid-IR Images of the Post-Asymptotic Giant Branch Star HD161796

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We present ground based images in the 10μm window of the post-AGB star HD161796. The images show an almost circular ring of emission at 12.5μm and 10.5μm, with brightness enhancements consistent with dust in a toroidal distribution. The ring is brighter on the SE than the NW side. Combining the measured diameter of this ring with results of a radiative transfer code for circumstellar dust shells, we have determined uniquely a distance (1200pc) and luminosity (3600$L_\odot$) for this source, which imply that it must be a Population II star, in accord with earlier abundance determinations. These images imply that the star left the AGB only 240 years ago, and that it did so with a final phase of enormously enhanced, equatorially concentrated mass-loss.

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Molecular Rotational Line Profiles from Oxygen-Rich Red Giant Winds

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We have developed a radiative transfer model of the dust and gas envelopes around late-type stars. The gas kinetic temperature for each star is calculated by solving equations of motion and the energy balance simultaneously. The main processes include viscous heating and adiabatic and radiative cooling. Heating is dominated by viscosity as the grains stream outward through the gas, with some contribution in oxygen-rich stars by near-IR pumping of H_2O followed by collisonal deexcitation in the inner envelope. For O–rich stars, rotational H_2O cooling is a dominant mechanism in the middle part of the envelope, with CO cooling being less significant. We have applied our model to three well studied oxygen-rich red giant stars. The three stars cover a wide range of mass loss rate and hence they have different temperature structures. The derived temperature structures are used in calculating CO line profiles for these objects. Comparison of the dust and gas mass loss rates suggests that mass loss rates are not constant during the AGB phase. In particular, the results show that the low CO 1-0 antenna temperatures of OH/IR stars reflect an earlier phase of much lower mass-loss rate.

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Multiple outflows in the compact bipolar planetary nebula M1-16

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Extensive observations of the molecular gas in the young, compact planetary nebula M1-16 have been made, using the Swedish-ESO-Submillimeter Telescope. A map of the CO J=2-1 emission shows that the molecular envelope contains both a slow and a fast outflow with expansion velocities of 19 km s^{-1} and >34 km s^{-1} respectively. The slow outflow is mildly elliptical while the fast molecular outflow is bipolar. This fast outflow is roughly aligned with the very fast outflows recently found in the optical while the long axis of the slow elliptical outflow is roughly orthogonal to the optical outflow axis. The kinematic time-scales of the CO fast outflow and the optical very-fast outflow agree closely, supporting the view that the former represents material in the slow outflow accelerated by the very-fast outflow. The kinematic signature of a disk expanding with about 15.5 km s^{-1} can also be seen in the CO J=2-1 data. The mass-loss rate (a) for the slow outflow is $\geq 2.8 \times 10^{-5}$ $M_\odot$/yr and possibly as large as 9×10^{-5} $M_\odot$/yr, (b) for the fast outflow, is $\geq 5 \times 10^{-6}$ $M_\odot$/yr and (c) for the very fast optically-visible outflow is $\approx 5 \times 10^{-7}$ $M_\odot$/yr. The disk mass is $\approx 6 \times 10^{-3}$ $M_\odot$. Grain photoelectric heating results in temperatures of 20-70 K in molecular gas of the slow outflow. The $^{13}C/^{12}C$ abundance ratio in M1-16 is found to be 0.33, quite possibly the highest found for any evolved object.

Upper limits for the $^{18}O/^{16}O$ and $^{17}O/^{16}O$ ratios were found to be consistent with the values found in AGB stars. A search for other molecular species is M1-16 resulted in the detection of the high-excitation species HCN, CN, ^{13}CN, HCO^+, and $H^{13}CO^+$ and possibly N_2H^+. Both the HCO^+/HCN and CN/HCN line-intensity ratios are enhanced, the former by a very large factor, over the values found in the envelopes of AGB stars, probably as a result of enhancement of the CN and HCO^+ abundances due to photo-chemistry induced by the stellar UV. The CS J=2-1, SiO J=2-1 (v=0) and SiS J=6-5 lines were not detected to low levels. For the high-excitation molecules, adequate collisional excitation of rotational levels and survival against photodissociation by the UV radiation requires significant clumping of the molecular gas into clumps with H_2 densities $\sim 10^5$ cm^{-3}. The IRAS fluxes of M1-16, assuming negligible contribution from line emission, imply the presence of about $(1.7 - 0.4) \times 10^{-3}$ $M_\odot$ of cool dust (temperature around 50 K) and a smaller quantity, $(2.7 - 3.1) \times 10^{-6}$ $M_\odot$ of warmer dust (temperature around 125 K) for a power-law emissivity index p=1-2.

The evolutionary nature of M1-16 cannot be explained by existing single-star models of post-AGB evolution. The very high $^{13}C/^{12}C$ abundance ratio in M1-16 suggests a possible evolutionary connection between M1-16 and the rare class of J-type silicate-carbon stars which also have high $^{13}C/^{12}C$ ratios and are thought to be binary systems with accretion disks.

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A deep VLA search for OH (1612 MHz) maser sources in the galactic plane

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The results of a VLA OH (1612 MHz) search for OH/IR stars in 7 fields along the galactic plane are presented. Forty-four sources were detected of which 35 were not previously known. It is shown that "blind" radio interferometric observations (such as with the VLA) are capable of filling up the gap in the IRAS based OH surveys near the galactic plane. This is important for the dynamical modelling of the disc and bulge of our Galaxy. It is also demonstrated that the high resolution of a synthesis telescope is needed to avoid confusion in the galactic plane. Most detected sources are likely to be young ($\lesssim$ 1 Gyr) and massive ($M_{\rm ms} > 2 - 3 M_\odot$)

evolved stars and have high expansion velocities ($v_{\rm exp} > 14.5$ km/s) and small deviations (< 10 km/s) from galactic rotation. Like Baud et al. (1981) we find a peak in the number of sources around $l = 25°$, a region associated with active star formation and a low number of stars at $l = 5°$ and $10°$.

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Dissertation Abstracts

Numerical models for the formation of aspherical Planetary Nebulae

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This thesis deals with the gasdynamics of aspherical planetary nebulae (PNe). Using a numerical gasdynamics solver, the formation of these PNe is followed and compared to observations. The basic assumption is that the PN forms through the interaction of a spherical fast (post-AGB) wind with an aspherical, but axisymmetric, slow (AGB) wind (generalized interacting winds mechanism). In the thesis various types of models each of increasing complexity, are treated.

After an introductionary chapter, the second chapter deals with non-radiative ('adiabatic') models and describes the numerical method used. Chapter 3 contains a description of which radiation processes (ionization/recombination, heating/cooling) were included and how. The next chapter (4) looks at one-dimensional (spherical) radiative models in which likely PAGB evolution tracks of the central star and its fast wind are used. The various effects of ionization and wind-wind interaction are discussed and some study is made of which type of AGB mass loss history fits typical observed PNe best.

Chapter 5 again considers aspherical models, this time including radiation effects, but using a non-evolving central star and fast wind. Synthesized images and long slit spectra in various lines are presented and compared to observations. The sixth chapter shows the results of some aspherical simulations in which the evolutionary effects of the central star are taken into account. These models show that the differential ionization of the slow wind may help in creating aspherical nebulae early on. The observed property that surrounding envelopes are in general less aspherical than the core nebula is also reproduced. The final chapter (7) summarizes the results from the thesis.

Defence took place on October 21st, 1993 *To obtain a copy, please contact* g_mellema@ast.ma.umist.ac.uk

Miras and OH/IR stars as Probes of the Galaxy

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The work described in this thesis has two main aspects. First the evolution of these late type stars is studied and especially how it is effected by mass loss. A second aspect is the study of structure and the history of our Galaxy from the interpretation of the nature of the Miras and OH/IR stars. For this reason AGB stars are studied in different fields in our Galaxy.

A basic dispute in the study of the evolution of Miras is whether they increase their mass loss and whether an increase in the period is connected with this. To study this, a direct comparison of different types of Long Period Variables is necessary. In Chapter 2 a sample of optically detected LPVs is compared with a sample of variables selected from the IRAS PSC. These variables are all selected in a field towards the galactic bulge. The

study is mostly based on infrared photometry in the range of 1.2 to 13 μm which were performed as part of an ESO Key Programme. The main conclusion is that the distributions of the apparent bolometric magnitudes differ less than what is expected on basis of the Mira period-luminosity relation. This is explained by assuming that, because of the loss of considerable amounts of mass the star has obtained a longer period of pulsation and, because the mass loss occurred in a short time, the luminosity has hardly increased. We therefore conclude that the IRAS sources have evolved from the Miras and that throughout this process mass loss increases. The spatial distribution of the Miras and the IRAS sources are very similar to that of the late type M giants. The metal poor RR Lyrae have a clearly different distribution. From model calculations in the literature we estimate that the long-period variable AGB stars are more than 10 Gyr old and originate from Main Sequence stars of about 1 $M_{\odot}$. This makes these LPVs comparable in age to the metal poor Globular cluster population (16 Gyr).

An infrared study of OH/IR stars in the galactic centre is presented in Chapter 3. These sources have all been detected as OH (1612 MHz) maser sources and part of them have been monitored at 18 cm. Infrared imaging was performed instead of standard photometry because of the high crowdedness in this field. On the basis of properties such as periods, infrared colours and luminosities it is shown that the OH/IR stars in the centre differ little from the same type of objects in the bulge of the Galaxy. It is further shown that a period-luminosity relation may exist for OH/IR stars, but that it differs significantly from the extrapolation of the (LMC) Mira period-luminosity relation (Feast et al 1989). Evidence is presented that the OH/IR stars with a higher metallicity have a kinematically flatter distribution.

OH/IR stars are good tracers of galactic structures such as the disc of our Galaxy. The modelling of the distribution of stars in the disc and the kinematics of these stars is hampered by the fact that surveys in the galactic plane suffer from the high density of sources. For this reason a VLA study to survey the OH/IR stars along the galactic plane was started. In Chapter 4 the results of a deep search with the VLA in 7 fields along the galactic plane is discussed. Main conclusions are that such interferometric searches are indeed very successful and can be used to complement the already existing OH surveys. The distribution along the plane is certainly not simply an exponential function of galactic radius, but is dominated by places of active star formation as in the molecular ring.

In the final chapter the OH/IR stars in the outer Galaxy are discussed. A sample of OH/IR stars was selected from the IRAS PSC on the basis of their colours. One of the main goals of this project was to study a cutoff in the radial distribution of OH/IR stars outside the solar circle and the presence of a second component: the thick disc (Habing 1988). New, groundbased infrared observations and OH data from the literature show that although the selection of AGB stars on the basis of a colour criterion from the IRAS PSC is very successful in the direction of the inner Galaxy, this is not the case outside the solar circle and that different types of objects like Carbon stars but also non-AGB objects have been included in the sample. The presence of such non-AGB objects in the sample is the main reason why Habing (1988) had to include a second component in his analysis of the disc structure. As the non-AGB objects have different energy distributions and luminosities from the OH/IR stars, the assumptions used by Habing to derive the distances to the IRAS sources were not correct. The small number of OH/IR stars outside the solar circle are most likely of a high mass ($M_{init} >$ 2-3 $M_{\odot}$). It is demonstrated that they have lower dust-mass loss rates and that this may be caused by a lower metallicity of these stars.

For copies of the thesis, contact blommaer@iap.fr*, IAP, 98bis Blvd Arago, 75014 Paris*

Meetings

March 11 "Pre Planetary Nebulae and Planetary Nebulae"

RAS meeting in London.
Organizers : Alex Raga & Tom Millar (acr or tjm @ast.ma.umist.ac.uk).

New Jobs

POSTDOCTORAL RESEARCH POSITION

Columbia Astrophysics Laboratory
Columbia University
538 W. 120th Street
New York, NY 10027
Attention: Prof. Arlin P.S. Crotts

A postdoctoral astrophysicist is sought to study a large body of data on the circumstellar envelope of SN 1987A, in anticipation of our watching this nebula be overtaken by the ejecta from the SN explosion in the next five to ten years. We have collected a large body of high-resolution imaging, echelle spectroscopy, and some polarization data at the Las Campanas 100" and CTIO 4-meter telescopes, in collaboration with Drs. S.R. Heathcote and W.E. Kunkel. The successful candidate would help analyze the recombination radiation across this nebula, the propagation of light echoes, and the properties of the circumstellar dust and gas. The successful applicant can also devote 50% of their research time to other projects. The appointment will be for one year, extendible to two years, with a salary of $34,000 (plus benefits, including access to University housing). Personal research funds and a Sparc workstation will be provided. Other resident researchers in related fields include N.H. Baker (stellar evolution), D.J. Helfand (SN remnants), J. Patterson (binary star evolution), K. Prendergast (ISM hydrodynamics), R.M. Rich (AGB stars, populations), A. Tomaney (novae), W. van der Veen (AGB/post-AGB stars), J. Xu (SN light echoes).

Please send a vita, description of relevant research interests and experience, publication list and the names of three colleagues willing to write letters of reference, by 1 March 1994. Columbia University is an equal Opportunity Employer and participates in the Affirmative Action Program.

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