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Abstracts of recently accepted papers

Infrared Spectroscopy of Five Short-Period Miras and the Peculiar Mira Z Oph

T. Lebzelter[1], *K.H. Hinkle*[2] *and J. Hron*[1]

[1] Institute for Astronomy, Türkenschanzstr.17, A-1180 Vienna, Austria

[2] Kitt Peak National Observatory, National Optical Astronomy Observatory

Time-series 2.0-2.5 μm infrared spectra have been observed for Miras with periods less than 200 days. Some of these stars are high velocity and metal poor. We have also observed the peculiar, possibly metal-poor Mira, Z Oph. Velocities, excitation temperatures, and $^{12}C/^{13}C$ have been determined for these stars. These results are compared with similar data for bright, field Miras. We find Z Oph to be a metal-poor Mira of very low mass-loss rate. All Miras regardless of period, metallicity, or chemical abundance have the same pulsation velocity amplitude. The mode of pulsation is discussed.

Accepted by Astronomy & Astrophysics

For preprints, contact lebzelter@astro.univie.ac.at *or via WWW on* http://www.ast.univie.ac.at/fzi/AGB/agbtl.html

ISO observations of IRAS 16594−4656: a new proto-planetary nebula with a strong 21 micron dust feature

P. García-Lario[1], *A. Manchado*[2], *A. Ulla*[3] *and M. Manteiga*[3]

[1] ISO Data Centre. Villafranca del Castillo. Apartado de Correos 50727. E-28080 Madrid, Spain

[2] Instituto de Astrofísica de Canarias, E-38200 La Laguna, Tenerife, Spain

[3] Departamento de Física Aplicada. Facultade de Ciencias. Campus Marcosende-Lagoas. Universidade de Vigo. Apartado de Correos 874. E-36200 Vigo, Pontevedra, Spain

Based on ISO SWS+LWS observations, IRAS 16594−4656 is identified as a new member of the rare class of C-rich proto-planetary nebulae with the 21 μm dust feature in emission. In addition, the major PAHs emission bands at 3.3, 6.2, 7.7, 8.6 and 11.3 μm are detected, together with unusually strong features at 12.6 and 13.4 μm, very rarely observed, attributed to PAHs species with a high degree of hydrogenation.

The shapes and relative intensities of the various features found are consistent with a mixed population of transient decomposition products of large hydrogenated amorphous carbonaceous (HAC) grains, consisting of fullerenes with a different degree of hydrogenation, which we suggest to be the main carriers of the strong 21 μm feature, and a combination of small and large partially dehydrogenated cationic PAHs molecules excited by the visible radiation coming from the central star.

Additional features corresponding to crystalline silicates (mostly pyroxenes) are also tentatively detected, together with a possible very broad unidentified emission feature centered around 30 μm, previously reported to appear in combination with the 21 μm feature in other proto-planetary nebulae candidates.

The combination of features corresponding to O-rich and C-rich dust grains found, if real, would suggest a recent change to a C-rich chemistry in the outer envelope of IRAS 16594−4656.

With the help of optical ground-based spectroscopy and recently obtained HST images we identify IRAS 16594−4656 as a new transition object between the AGB and the PN stage. The ground-based optical spectrum shows only the Balmer lines in emission and a faint, probably shocked excited, [O I] emission over a very red continuum where strong, probably circumstellar, DIBs at 5780 and 6281−6284 Å are clearly seen. HST WFPC2 continuum images reveal the presence of a bright central star surrounded by a bipolar reflection nebula with a multiple-axis morphology and a maximum size of $\sim 5'' \times 11''$.

Accepted by Astrophysical Journal

Preprints can be obtained by contacting pgarcia@iso.vilspa.esa.es *or via WWW on*
http://www.iso.vilspa.esa.es/science/publications.html

AGB stars in binaries and their progeny

A. Jorissen

Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles, C.P. 226, Boulevard du Triomphe, B-1050 Bruxelles, Belgium

It is currently admitted that an AGB star in a binary system is likely to pollute its companion with carbon- and s-process-rich matter. After the AGB star has faded into an unconspicuous white dwarf, the polluted companion enters the zoo of stars with chemical peculiarities. In this paper, the progeny of AGB stars in binary systems are identified among existing spectroscopic classes (Abell 35-like, binary post-AGB, WIRRing, dwarf Ba and C, subgiant CH, Ba, CH, S, yellow symbiotics) and their filiation is discussed from the properties of their eccentricity – period diagrams.

Invited review presented at IAU Symp. 191, AGB Stars, edited by T. Le Bertre, A. Lèbre and C. Waelkens

Preprints can be obtained by contacting ajorisse@astro.ulb.ac.be
or via WWW on http://astro.ulb.ac.be/Htm/ps.htm

Supernova 1987A: Rotation and a Binary Companion

T.J.B. Collins[1], *Adam Frank*[2], *J.E. Bjorkman*[3] *and Mario Livio*[4]

[1] Laboratory for Laser Energetics,
University of Rochester, 250 E. River Rd., Rochester, NY 14623-1299

[2] Dept. of Physics and Astronomy and C. E. K. Mees Observatory,
University of Rochester, Rochester, NY 14627-0171

[3] Dept. of Physics and Astronomy, Ritter Observatory,
University of Toledo, Toledo, OH 43606-3390

4 Space Science Telescope Institute, 3700 San Martin Dr. Baltimore, MD 21218

In this paper we provide a possible link between the structure of the bipolar nebula surrounding SN1987A and the properties of its progenitor star. The methods used in this paper can be applied to all forms of

bipolar outflow including Planetary Nebulae. A Wind Blown Bubble (WBB) scenario is employed, in which a fast, tenuous wind from a Blue Supergiant expands into a slow, dense wind, expelled during an earlier Red Supergiant phase. The bipolar shape develops due to a pole-to-equator density contrast in the slow wind (i.e. the slow wind forms a *slow torus*). We use the Wind Compressed Disk (WCD) model of Bjorkman & Cassinelli (1992) to determine the shape of the slow torus. In the WCD scenario, the shape of the torus is determined by the rotation of the progenitor star. We then use a self-similar semi-analytical method for wind blown bubble evolution to determine the shape of the resulting bipolar nebula.

We find that the union of wind-compressed-disk and bipolar-wind-blown-bubble models allows us to recover the salient properties of SN1987A's circumstellar nebula. In particular, the size, speed and density of SN1987A's inner ring are easily reproduced in our calculations. An exploration of parameter space shows that the red supergiant progenitor must have been rotating at $\gtrsim$0.3 of its breakup speed. We conclude that the progenitor was most likely spun up by a merger with a binary companion. Using a simple model for the binary merger we find that the companion is likely to have had a mass $\gtrsim 0.5 M_{\odot}$.

Accepted by ApJ

Preprints can be obtained by contacting afrank@pas.rochester.edu *or via WWW on* http://adress/directory.html *or via anonymous ftp on* ftp://adress/directory/publication.tar

Mass loss and AGB evolution in extra-galactic stellar populations

Albert A. Zijlstra

UMIST, Department of Physics, Manchester M60 1QD, UK The effect of metallicity on the AGB mass loss is reviewed. Observations have mainly been limited to the Magellanic Clouds but are observationally feasible throughout the Local Group. Expansion velocities are predicted to depend strongly on Z but the peak mass-loss rates appear not to. The Mira PL relation shows no evidence for a Z dependence, giving a powerful potential distance indicator. I derive a distance modulus to the LMC of $m - M = 18.63 \pm 0.09$ as well as a bright calibration for the Horizontal Branch in globular clusters. Finally, the predicted initial-final mass relation at low Z is shown to give rise to higher mass remnants. This would result in an increased supernova rate in young, low-Z populations, such as found in the early Universe.

invited review, IAU Symp. 191, AGB Stars (Montpellier 1998)

Preprints can be obtained from aaz@iapetus.phy.umist.ac.uk

A critical look at the role of AGB stars in stellar population synthesis

A. Lançon

Observatoire astronomique, Université L. Pasteur & CNRS, UMR 7550, 11 rue de l'Université, 67 000 Strasbourg, France

Asymptotic giant branch stars are essential contributors to the near and mid-IR emission of intermediate age (10^8-10^9 yr old) stellar populations. Detecting this light will set constraints on the star formation history in galaxies and, conversely, the search for AGB signatures in well studied populations will help us reduce some of the still large uncertainties in AGB models. This paper reviews how AGB stars are currently included in population synthesis models and which spectral features can be used to identify their emission in galaxy light; targets for observational tests are suggested, and some observational and theoretical difficulties are discussed.

Review to be published in IAU Symp. 191 on AGB stars, PASP Conf. Series.

Preprints can be obtained by contacting lancon@astro.u-strasbg.fr *or via WWW on* http://astro.u-strasbg.fr/lancon/popul.html

The kinematics of point-symmetric planetary nebulae

M.A. Guerrero[1], *R. Vazquez*[2] *and J.A. López*[3]

[1] Instituto de Astrofísica de Canarias
Vía Láctea s/n, La Laguna 38200, Tenerife, Spain

[2] Instituto de Astrofísica de Andalucía, CSIC
Apdo. Postal 3004, 18080 Granada, Spain

[3] Instituto de Astronomía, UNAM
Apdo. Postal 877, 22800 Ensenada, B.C., México

Four planetary nebulae (PNe) with conspicuous point-symmetric morphology are studied in this paper through high quality imagery and long-slit echelle spectroscopy. Point-symmetry is also found in the velocity space and this is related to particular forms of bipolar collimated outflows. Morphology and kinematics together reveal the presence of collimated bipolar ejections in an episodic way with indications of rotation or displacement of the symmetry axis of the outflow.

Point-symmetry is currently known to occur in a wide variety of PNe and the convenience of a re-evaluation of point-symmetric PNe as a main morphological class is pointed out.

Accepted by The Astronomical Journal

Preprints can be obtained by contacting mar@ll.iac.es *or via WWW on*
http://www.iac.es/publicaciones/preprints.html
or http://bufadora.astrosen.unam.mx:80/ jal/PNPS/

Planetary nebulae in M32 and the bulge of M31: Line intensities and oxygen abundances

Michael G. Richer[1], *Grażyna Stasińska*[2], *and Marshall L. McCall*[3]

[1] Instituto de Astronomía, UNAM, Apartado Postal 70-264, 04510 México, D.F., México

[2] DAEC, Observatoire de Meudon, 5 Place Jules Janssen, F-92195 Meudon Cedex, France

[3] Dept. of Physics & Astronomy, York University, 4700 Keele Street, Toronto, Ontario, Canada M3J 1P3

We present spectroscopy of planetary nebulae in M32 and in the bulge of M31 that we obtained with the MOS spectrograph at the Canada-France-Hawaii Telescope. Our sample includes 30 planetary nebulae in M31 and 9 planetary nebulae in M32. We also observed one H II region in the disk of M31. We detected [O III]λ4363 in 18 of the planetary nebulae, 4 in M32 and 14 in the bulge of M31. We use our line intensities to derive electron temperatures and oxygen abundances for the planetary nebulae.

Accepted by Astronomy & Astrophysics Supplement Series.

Preprints can be obtained by contacting richer@astroscu.unam.mx

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Michael G. Richer[1], *Grażyna Stasińska*[2], *and Marshall L. McCall*[3]

[1] Instituto de Astronomía, UNAM, Apartado Postal 70-264, 04510 México, D.F., México

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Accepted by Astronomy & Astrophysics Supplement Series.

Preprints can be obtained by contacting richer@astroscu.unam.mx *or via WWW on*
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MACHO observations of LMC red giants: Mira and semi-regular pulsators, and contact and semi-detached binaries

P.R. Wood[1] *and the MACHO COLLABORATION*

[1] Mount Stromlo and Siding Spring Observatories, Australian National University, Private Bag, Weston Creek PO, ACT 2611 Australia

The MACHO data base has been used to examine light curves of all red giant stars brighter than $M_{\rm bol} \sim$ -2 in a 0.5deg×0.5deg area the LMC bar. Periods, often multiple, have been searched for in all stars found to be variable. Five distinct period-luminosity sequences have been found on the low mass ($M \lesssim 2.25 M_{\odot}$) giant branch. Comparison of observed periods, luminosities and period ratios with theoretical models identifies Miras unambiguously as radial fundamental mode pulsators, while semi-regular variables can be pulsating in the 1st, 2nd or 3rd overtone, or even the fundamental. All these variables lie on just 3 of the 5 distinct sequences, and they all appear to be on the AGB.

The fourth sequence contains red giants on the first giant branch (FGB) or at the red end of the core-helium burning loops of intermediate mass stars ($M \gtrsim 2.25 M_{\odot}$). The light curves of these stars strongly suggest that they are contact binaries, and they make up ~0.5% of stars within 1 mag. of the FGB tip. Stars on the fifth sequence show semi-regular, eclipse-like light curves. The light curves and periods of these stars suggest that they are in semi-detached binaries, transfering mass to an invisible companion via a stellar wind or Roche lobe overflow. They make up ~25% of AGB stars. If the existence of these red giant contact and semi-detached binaries is confirmed, then extant theories of binary star evolution will require substantial modification.

Contribution to IAU Symposium 191, "AGB Stars"

Preprints can be obtained by contacting wood@mso.anu.edu.au *or via anonymous ftp on*
ftp://merlin.anu.edu.au/pub/wood/papers/iau191_paper.ps.gz

On the validity of the core-mass luminosity relation for TP-AGB stars with efficient dredge-up

F. Herwig[1,2]*, D. Schönberner*[2]*, T. Blöcker*[3]

[1] Universität Potsdam, Institut für Physik, Astrophysik, Am Neuen Palais 10, D-14469 Potsdam, Germany

[2] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, D-14482 Potsdam, Germany

[3] Max–Planck–Institut für Radioastronomie, Auf dem Hügel 69, D–53121 Bonn, Germany

We investigate the validity of the core mass - luminosity relation (CMLR), originally described by Paczyński (1970), for asymptotic giant branch stars under the presence of third dredge-up events. We find, that models with efficient third dredge-up with less massive cores than those associated with hot bottom burning (Blöcker & Schönberner 1991) do not obey the linear CMLR.
Complete evolutionary calculations of thermal pulse stellar models which consider overshoot according to an exponential diffusive algorithm show systematically larger third dredge-up for lower core masses ($0.55 M_{\odot} < M_{\rm H} < 0.8 M_{\odot}$) than any other existing models. We present and discuss the luminosity evolution of these models.

Accepted by Astronomy & Astrophysics (Letter to the Editor)

Preprints can be obtained by contacting fherwig@astro.physik.uni-potsdam.de,
via WWW on http://www.astro.physik.uni-potsdam.de/astro_literatur.html
and via anonymous ftp on 134.104.20.101 *in* /pub/papers/Herwig_etal_AaA_mhl_1998/HSB98.ps.gz

The separation of the stars in the binary nucleus of the planetary nebula Abell 35

A. A. Gatti[1], *J. E. Drew*[1], *R. D. Oudmaijer*[1], *T. R. Marsh*[2], *A. E. Lynas-Gray*[3]

[1] Imperial College of Science, Technology and Medicine, Blackett Laboratory, Prince Consort Road, London, SW7 2BZ, U.K.

[2] Department of Physics, Southampton University, Southampton S09 5NH, U.K.

[3] Department of Physics, University of Oxford, Nuclear Physics Laboratory, Keble Road, Oxford, OX1 3RH, U.K.

Using the Planetary Camera on board the Hubble Space Telescope we have measured the projected separation of the binary components in the nucleus of the planetary nebula Abell 35 to be larger than $0.08''$ but less than $0.14''$. The system was imaged in three filters centered at 2950Å, 3350Å and 5785Å. The white dwarf primary star responsible for ionizing the nebula is half as bright as its companion in the 2950Å filter causing the source to be visibly elongated. The 3350Å setting, on the other hand, shows no elongation as a result of the more extreme flux ratio. The F300W data allows the determinination of the binary's projected separation. At the minimum distance of 160 parsec to the system, our result corresponds to 18±5 AU. This outcome is consistent with the wind accretion induced rapid rotation hypothesis, but cannot be reconciled with the binary having emerged from a common-envelope phase.

Accepted by Monthly Notices of the Royal Astronomical Society

Preprints can be obtained by contacting gattiaa@ic.ac.uk

Carbon stars in populations of different metallicity

M.A.T. Groenewegen

Max-Planck-Institut für Astrophysik, Karl-Schwarzschild-Straße 1, D-85740 Garching, Germany

Our current knowledge of carbon stars in the Local Group and beyond, is discussed. Although many carbon stars and late M-stars have been identified in external galaxies a coherent understanding in terms of the chemical evolution- and star formation rate-history of a galaxy is still largely lacking. Issues that need to be addressed are: 1) for some of the larger galaxies only a small fraction in area has been surveyed so far, 2) surveys have been conducted using different techniques, and may be incomplete in bolometric magnitude, 3) only for some galaxies is there information about the late M-star population, 4) not all galaxies in the Local Group have been surveyed, 5) only for a sub-set of stars are bolometric magnitudes available.

From the existing observations one can derive the following: the formation of carbon stars is both a function of metallicity and star-formation. In galaxies with a similar star-formation rate history, there will be relatively more carbon stars formed in the system with the lower metallicity. On the other hand, the scarcity of AGB type carbon stars in some systems with the lowest metallicity indicates that these galaxies have had a low, if any, star-formation rate history over the last few Gyrs.

Invited review at IAU Symposium 191 on AGB stars

For preprints, contact
groen@mpa-garching.mpg.de, *or look at*
http://www.mpa-garching.mpg.de/~groen/groen.html

Jets and the shaping of the giant bipolar envelope of the planetary nebula KjPn 8

W. Steffen[1] *and J.A. López*[2]

[1] Department of Physics and Astronomy, University of Manchester, Oxford Rd., Manchester, M13 9PL, UK

[2] Instituto de Astronomía, UNAM, Apdo. Postal 877, Ensenada, B.C. 22800, México.

A hydrodynamic model involving cooling gas in the stagnation region of a collimated outflow is proposed for the formation of the giant parsec-scale bipolar envelope that surrounds the planetary nebula KjPn 8. Analytical calculations and numerical simulations are presented to evaluate the model. The envelope is considered to consist mainly of environmental gas swept-up by shocks driven by an episodic, collimated, bipolar outflow. In this model, which we call the "free stagnation knot" mechanism, the swept-up ambient gas located in the stagnation region of the bow-shock cools to produce a high density knot. This knot moves along with the bow-shock. When the central outflow ceases, pressurization of the interior of the envelope stops and its expansion slows down. The stagnation knot, however, has sufficient momentum to propagate freely further along the axis, producing a distinct nose at the end of the lobe. The model is found to successfully reproduce the peculiar shape and global kinematics of the giant bipolar envelope of KjPn 8.

Accepted by The Astrophysical Journal.

Preprints can be obtained by contacting contact-author@internet-adress *or via WWW on*
http://bufadora.astrosen.unam.mx:80/ jal/K8MOD/ *or via anonymous ftp on*
ftp://adress/directory/publication.tar

Detection of warm SO_2 gas in oxygen-rich AGB stars

I. Yamamura[1]*, T. de Jong*[2,1]*, T. Onaka*[3]*, J. Cami*[4,1]*, L.B.F.M. Waters*[1,4]

[1] Astronomical Institute 'Anton Pannekoek', University of Amsterdam, Kruislaan 403, 1098 SJ, Amsterdam, the Netherlands

[2] SRON-Utrecht, Sorbonnelaan 2, 3584 CA Utrecht, The Netherlands

[3] Department of Astronomy, School of Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, 113-0033 Tokyo, Japan

[4] SRON-Groningen, P.O.Box 800, 9700 AV Groningen, the Netherlands

We report the discovery of the ν_3 band of SO_2 at 7.3 μm in the ISO/SWS spectra of oxygen-rich AGB stars. The band is clearly detected in three stars, UX Cyg, *o* Cet and T Cep, and marginally detected in at least four other stars. The band is seen in absorption in UX Cyg, while it is in emission in *o* Cet. Seven spectra of T Cep taken at different phases show that the feature changes from emission to absorption on a time scale of twice the pulsation period. Using an LTE model, we find that the excitation temperature of SO_2 is typically 600 K, and that in T Cep the molecule occupies a region with dimensions of several stellar radii. The total number of molecules contained in this region is of order 10^{47}, which requires a local gas density of at least 10^9 H_2 cm^{-3}, and possibly up to 10^{11} H_2 cm^{-3} depending on the SO_2 abundance. The variation with phase of the T Cep spectra can be explained by photodissociation of SO_2 molecules by soft UV photons.

Accepted by A&A Letter

Preprints can be obtained by by *contacting*
yamamura@astro.uva.nl *or via WWW on*
http://www.astro.uva.nl/yamamura/ *or via anonymous ftp on*
ftp://helios.astro.uva.nl/pub/yamamura/SO2/

Dynamic model atmospheres of AGB stars II. Synthetic Near Infrared Spectra of Carbon Stars

R. Loidl[1], *S. Höfner*[2], *U.G. Jørgensen*[2], *B. Aringer*[1]

[1] Institut für Astronomie der Universität Wien, Türkenschanzstraße 17, A-1180 Wien, Austria

[2] Niels Bohr Institute, Astronomical Observatory, Juliane Maries Vej 30, DK-2100 Copenhagen, Denmark

We have calculated synthetic opacity sampling spectra for carbon-rich Asymptotic Giant Branch (AGB) stars based on dynamic model atmospheres presented in the first paper of this series. We discuss how different model parameters influence the resulting synthetic spectra and how the spectra vary with phase. The molecules included are: CO, CH, CN, C_2, HCN, C_2H_2 and C_3. We show in which atmospheric layers the different molecules form, in an attempt to understand the qualitatively different variation with pulsation phase exhibited by various spectral features. Almost all features are blends of transitions from more than one molecule, and we therefore identify the most important transitions and molecules that contribute to the main spectral features from 0.5 to 12 μm. Furthermore, we demonstrate the effect on the individual spectral features due to the carbon depletion when dust is formed in the atmosphere.

Accepted by A & A

Preprints can be obtained by contacting loidl@astro.univie.ac.at
or via WWW on http://www.ast.univie.ac.at/~fzi/AGB/rita/science.html

Job opportunities

Research Fellow in Stellar Astrophysics

A Postdoctoral position is available with the Astrophysics Group at Monash University, Australia. The successful candidate will join an active group working on stellar evolution and nucleosynthesis, with particular emphasis on AGB stars. Relocation expenses may be available.

The salary is in the range $AUD 41993 to $AUD 45076, and the position is for 2 years duration.

For further information

- please send email to John Lattanzio johnl@flash.maths.monash.edu.au
- or visit http://www.maths.monash.edu.au/ johnl/Astro/job.html

Conference summary

Asymptotic Giant Branch Stars Conference Summary[1]

C. Waelkens[1], T. Le Bertre[2] and A. Lèbre[3]

[1] Catholic University of Leuven, Belgium

[2] Observatory of Paris, France

[3] University of Montpellier II, France

IAU Symposium 191 on 'Asymptotic Giant Branch (AGB) Stars' was held in Montpellier, France, from August 27 to September 1, 1998. It was attended by 245 participants from 27 countries.

The AGB phase corresponds to the short stage during which intermediate-mass stars attain their highest luminosities, but also experience heavy mass loss which rapidly conducts them towards the planetary-nebula phase and the final cooling to white dwarfs. AGB stars are most revealing for critical issues in stellar structure, nucleosynthesis, and evolution, and their circumstellar envelopes are important interfaces between stellar and interstellar media. Since they correspond to the most luminous stage of a dominant stellar population, understanding AGB stars is necessary to understand external galaxies with old populations.

The timing of the conference was fortunate, in the sense that first mature results were presented from long-standing ambitious projects in the field of large infrared surveys, infrared spectroscopy from space, and high-angular-resolution observations from the near UV to the mm domain. A cornerstone of the conference was the confrontation of studies of stardust in AGB star envelopes, where dust is formed, and in our solar system, where it can be analysed directly.

Several high-angular observations, some of them time-dependent, of Miras have been obtained, revealing asymmetries already in early stages. The interpretation of these data in terms of linear diameters is hampered by the fact that the huge sizes of the stars imply that their angular diameters are a multiple of their parallaxes and by the strong wavelength dependence of the observed extension, diameters in the continuum being sometimes more than three times smaller than in strong molecular bands. The issue of the pulsation mode of Miras remains more controversial than ever. Dynamical models of the extended atmospheres and shells of AGB stars have attained a high level in sophistication and ask for increasing even further the remarkable angular resolution attained with interferometric devices.

The envelopes of AGB stars are the major factories of cosmic dust. Thanks to the observations with the Infrared Space Observatory (ISO) and to data obtained from laboratory astrophysics the prospect arises to perform detailed mineralogy of the grains. Before ISO astronomical silicates were considered to be essentially amorphous, but the conspicuous presence of crystalline silicates in the circumstellar shells of evolved, as well as young, stars triggered new laboratory research as well. The details of the transition of the grains from the circumstellar environments to the interstellar medium, where only the amorphous component has been observed so far, are mysterious.

A self-consistent theory for oxygen-rich dust formation, which would be able to explain these new data, is still lacking, but various attempts seem promising. On the other hand, the theory of carbon-rich dust formation appears to be on a solid basis, being able to reproduce the data, and even allowing for variability. In this field, astrophysics owes much to the literature on combustion, which does not appear on the shelves of the typical astronomer! Furthermore, when coupled with stellar evolution models, this theory seems able to explain the long term time dependence of the carbon-star mass-loss-rates.

Half a thousand of meteorites are not processed and thus presolar. A classical result of the study of these grains is the confirmation of the nucleation of graphite on TiC grains. Isotopic patterns of s-process elements are well

[1]Proceedings will be edited by T. Le Bertre, A. Lèbre & C. Waelkens and published in the *IAU Symposium Series* by the Astronomical Society of the Pacific

reproduced by models of nucleosynthesis in AGB stars. Measured silicon isotopic ratios in SiC grains indicate that many stellar sources are involved in the grains that occurred in the solar nebula. However, the large grains that are observed as inclusions in meteorites are not easily understood in terms of modelling of AGB outflows; it was suggested that these grains originate in the disks that are observed around several AGB and post-AGB stars, that presumably are binary systems.

It now seems plausible that all chemically peculiar red giants and post-AGB stars, and maybe even most RV Tauri stars, are binaries. In wide systems wind accretion of s-process material accounts for the observed peculiarities, but a large number of closer systems requires non-standard binary evolution: not all interacting binaries become cataclysmic variables or merge. Many spectacular and therefore archetypical AGB and post-AGB objects turn out to be binaries, which should warn us that binarity may introduce an observational bias. A numerous population of very-long-period variables detected by the MACHO survey may imply, however, that interacting binaries are also quantitatively an important population.

On the theoretical side, the importance of mixing for dredge-up was pointed out. While hot-bottom-burning explains the lack of optically bright carbon stars in low-metallicity environments, the presence of luminous enshrouded carbon stars in the Magellanic Clouds is explained by the last dredge-ups in the more massive AGB stars. Studies of AGB stars in other external galaxies are now emerging, with a promising potential for stellar population studies.

To appear in the January 1999 issue of PASP

consult our web site on http://www.dstu.univ-montp2.fr/GRAAL/agb98-1.html