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Abstracts of recently accepted papers

ISO-SWS spectra of the C-rich AGB star R Scl and dynamical model atmospheres

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We have monitored the spectral variations of the carbon rich AGB star R Scl in the $2-45\,\mu$m range using the ISO-SWS instrument. We have also computed hydrostatic and hydrodynamic model atmospheres and corresponding synthetic spectra representative for two phases of R Scl. There is good qualitative agreement between observations and models in the near IR. This demonstrates the theoretical progress and the potential of analysing carbon star spectra with self-consistent dynamical models.

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The planetary nebulae populations in five galaxies: abundance patterns and evolution

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We have collected photometric and spectroscopic data on planetary nebulae (PNe) in 5 galaxies: the Milky Way (bulge), M31 (bulge), M32, the LMC and the SMC.

We have computed the abundances of O, Ne and N and compared them from one galaxy to another. In each Galaxy, the distribution of oxygen abundances has a large dispersion. The average O/H ratio is larger in the M31 and the Galactic bulge PNe than in those in the Magellanic Clouds. In a given galaxy, it is also larger for PNe with [O III] luminosities greater than 100 $L_{\odot}$, which are likely to probe more recent epochs in the galaxy history. We find that the M31 and the Galactic bulge PNe extend the very tight Ne/H–O/H correlation observed in the Galactic disk and Magellanic Clouds PNe towards higher metallicities. We note that the anticorrelation between N/O and O/H that was known to occur in the Magellanic Clouds and in the disk PNe is also marginally

found in the PNe of the Galactic bulge. Furthermore, we find that high N/O ratios are higher for less luminous PNe. In M32, all PNe have a large N/O ratio, indicating that the stellar nitrogen abundance is enhanced in this galaxy.

We have also compared the PN evolution in the different galactic systems by constructing diagrams that are independent of abundances, and have found strikingly different behaviours of the various samples.

In order to help in the interpretation of these data, we have constructed a grid of expanding, PN photoionization models in which the central stars evolve according to the evolutionary tracks of Blöcker (1995). These models show that the apparent spectroscopic properties of PNe are extremely dependent, not only on the central stars, but also on the masses and expansion velocities of the nebular envelopes.

The main conclusion of the confrontation of the observed samples with the model grids is that the PN populations are indeed not the same in the various parent galaxies. Both stars and nebulae are different. In particular, the central stars of the Magellanic Clouds PNe are shown to evolve differently from the hydrogen burning stellar evolutionary models of Blöcker (1995). In the Galactic bulge, on the other hand, the behaviour of the observed PNe is roughly compatible with the theoretical stellar evolutionary tracks. The case of M31 is not quite clear, and additional observations are necessary. It seems that the central star mass distribution is narrower for the M31 PNe than for the Galactic bulge PNe.

We show that spectroscopy of complete samples of PNe down to a factor 100 below the maximum luminosity would help to better characterize the PN central star mass distribution.

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Preprints can be obtained by contacting grazyna@obspm.fr
or via anonnymous ftp on ftp://ftp.obspm.fr/transit/grazyna/pnpop

Extended cold dust emission at 1.3 mm from evolved stars

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We have performed maps of the 1.3 mm continuum emission from a sample of 16 evolved stars. We have detected emission from a total of 11 objects, two of which are new detections at this wavelength: M 1-92 and, tentatively, M 1-91. 4 objects in the sample, the bipolar nebulae M 2-9, OH 231.8+4.2, NGC 7027 and CRL 2688, show extended emission in the direction of their symmetry axis up to distances from the central star $\sim 10^{17}$ cm. We argue that most of this radio emissio is arising from cold dust present in the bipolar lobes. Extended emission has not been found in the direction perpendicular to the nebular axis (except probably for NGC 7027), therefore the equatorial torus/disk of dust probably present in this type of objects is not extended enough to be detected by our observations. The 1.3 mm emission map of NGC 7027 shows an extended structure elongated approximately in the equatorial plane. This component extends up to a distance from the nebula center of about 15″, and we think it could correspond to the outer region of the circumstellar disk of dust observed at shorter wavelengths in this source. In cases were extended components have been found, we estimate, assuming simplifying hypotheses, the temperature and mass of the dust. In the sources M 2-9, OH 231.8+4.2 and CRL 2688, the cold dust mass is $\sim 2\ 10^{-3}\ M_{\odot}$, while NGC 7027 seems to have a larger dust content, $\sim 10^{-2}\ M_{\odot}$. For M 2-9 and OH 231.8+4.2 the uncertainty factors of our estimations have values between 2 and 3.5. For CRL 2688 the errors can be as high as a factor 10, and for NGC 7027 the dust mass given could just be a lower limit. In all the well studied cases, the cold dust component represents a large fraction of the total dust mass in the envelope ($\gtrsim 50\%$) and is probably composed by relatively big grains (radii larger than 1 μm). We caution that the analysis of radio continuum emission can be very uncertain when not enough data on extent and spectral flux distribution exist.

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The Onset of Molecular Hydrogen Emission from Proto-planetary Nebulae

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This paper presents results obtained from high-resolution spectroscopy of the 2.1218 μm emission line of molecular hydrogen toward five bipolar pre-planetary nebulae. Our detections of IRAS 17441−2411 and AFGL 6815S bring to four, including AFGL 618 and AFGL 2688, the number of bipolar pre-planetaries that have been detected as sources of H_2 emission at 2.1218 μm. The spatially resolved H_2 line profile of AFGL 6815S suggests that the bulk of the detected emission arises in an expanding molecular torus surrounding the central star.

All of the H_2-emitting pre-planetary nebulae are found at low galactic latitudes — consistent with previous results for planetary nebulae — and have central stars with intermediate or early spectral types. We were unable to detect H_2 emission from the bipolar, post-main sequence sources OH231.8+4.2, IRAS 07131−0147, and IRAS 09371+1212, all of which have M-type central stars. These results suggest that the event that triggers the production of emission from shocked H_2 occurs at an intermediate evolutionary epoch in the post-asymptotic giant branch evolution of transition objects, after the generation of bipolar structure and before the nebular envelopes are ionized. From constraints imposed by the galactic distribution of H_2-emitting planetaries, we estimate distances to the four pre-planetary nebulae that display H_2 emission.

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Direct Detection of the Mira at the Heart of OH 231.8+4.2

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The evolved bipolar nebula OH 231.8+4.2 is host to a Mira variable star, QX Pup, at its core. We used the Diffraction-Limited Near-infrared Imaging (DLIRIM) system at Kitt Peak to obtain the first direct images of this star in the near-infrared. In subarcsecond resolution DLIRIM images at K (2.2 μm) and L′ (3.8 μm) the star is clearly detected and is well resolved from the surrounding nebulosity. The star lies midway between the lobes of the OH 231.8+4.2 reflection nebula, confirming previous inferences based on polarimetric imaging and nebular colors. In addition to betraying the location of the central Mira, these images reveal the detailed structure of OH 231.8+4.2, including a point symmetric system of jet-like features protruding from its polar lobes. The K−L′ color distribution of the nebula is consistent with reflection and extinction of near-infrared radiation from the Mira by dust grains larger than those characteristic of the interstellar medium. From the apparent K magnitude of the star, combined with its relatively well-determined distance (1300 pc) and the circumstellar extinction we infer from its measured K−L′ color, we estimate a mean absolute magnitude $M_K \sim -10.2$, comparable to Mira variables of similar ($\sim$ 700 day) period in the Large Magellanic Cloud. In this and other respects, the central Mira appears remarkably "normal" given its position at the heart of such an unusual object.

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Magnetic Field, Dust, and Axisymmetrical Mass Loss on the AGB

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I propose a mechanism for axisymmetrical mass loss on the asymptotic giant branch (AGB), that may account for the axially symmetric structure of elliptical planetary nebulae. The proposed model operates for slowly rotating AGB stars, having angular velocities in the range of $10^{-4}\omega_{\rm Kep} < \omega < 10^{-2}\omega_{\rm Kep}$, where $\omega_{\rm Kep}$ is the equatorial Keplerian angular velocity. Such angular velocities could be gained from a planet companion of mass $> 0.1 M_{\rm Jupiter}$, which deposits its orbital angular momentum to the envelope at late stages, or even from single stars which are fast rotators on the main sequence. The model assumes that dynamo magnetic activity results in the formation of cool spots, above which dust forms much easily. The enhanced magnetic activity toward the equator results in a higher dust formation rate there, and hence higher mass loss rate. As the star ascends the AGB, both the mass loss rate and magnetic activity increase rapidly, and hence the mass loss becomes more asymmetrical, with higher mass loss rate closer to the equatorial plane.

MNRAS, in press.

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On The Kinematics of Multiple-Shell Planetary Nebulae. I. Data and expansion velocities

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We present spatially resolved echelle spectroscopy, obtained at high spectral resolution, for 15 multiple-shell planetary nebulae. Most exhibit faint detached haloes (IC 1295, MA 3, M 2-2, M 2-40, NGC 6804, NGC 6826, NGC 6884, NGC 6891, NGC 7662, PM 1-295, and Vy 2-3). Furthermore, we have included some with an attached shell (IC 1454, K 1-20, K 3-73, and PM 1-276) to allow the comparison of the kinematic properties of the two subclasses of multiple-shell planetary nebulae. In addition, some of the nebulae in our sample show a triple shell structure composed of the bright main nebula and a combination of two attached shells (PB 9), one attached shell and one detached halo (NGC 6826, NGC 6891, NGC 7662, and Vy 2-3), or two detached shells (NGC 6804).

The radial velocity, the expansion velocities of each shell, and the turbulence contribution to the line width are presented. The expansion velocity has been worked out by modeling how much the width of a the Hα line decreases with the radius of the shell. The expansion velocity spans from 12 to $30\,{\rm km\,s^{-1}}$ for the detached haloes. It is worthwhile to note that the expansion velocities obtained by this method are greater than if they were computed with a thin-shell model, as previously done. In relation to the attached shells, their expansion velocities span from 10 to $30\,{\rm km\,s^{-1}}$. The turbulent contribution to the line width is smaller for haloes ($0\,{\rm km\,s^{-1}} \leq \sigma_{\rm tur} \leq 6\,{\rm km\,s^{-1}}$) than for attached shells ($0\,{\rm km\,s^{-1}} \leq \sigma_{\rm tur} \leq 15\,{\rm km\,s^{-1}}$). This suggests that large-scale hydrodynamic processes are more important in attached shells than in detached haloes.

We have also studied the kinematics of the detached haloes whose morphology is perturbed from a round shape to a dipole asymmetry, indicating its interaction with the surrounding interstellar medium. We found systematic differences between the kinematical behavior of the enhanced edge of the halo and the opposite side in these cases, thus revealing the kinematic effect of the interaction of the haloes with the interstellar medium.

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Bipolar Outflows and the Evolution of Stars

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Hypersonic bipolar outflows are a ubiquitous phenomena associated with both young and highly evolved stars. Observations of Planetary Nebulae, the nebulae surrounding Luminous Blue Variables such as η Carinae, Wolf Rayet bubbles, the circumstellar environment of SN 1987A and Young Stellar Objects all revealed high velocity outflows with a wide range of shapes. In this paper I review the current state of our theoretical understanding of these outflows.

Beginning with Planetary Nebulae considerable progress has been made in understanding bipolar outflows as the result of stellar winds interacting with the circumstellar environment. In what has been called the "Generalized Wind Blown Bubble" (GWBB) scenario, a fast tenuous wind from the central star expands into an ambient medium with an aspherical (toroidal) density distribution. Inertial gradients due to the gaseous torus quickly lead to an expanding prolate or bipolar shell of swept-up gas bounded by strong shock waves. Numerical simulations of the GWBB scenario show a surprisingly rich variety of gasdynamical behavior, allowing models to recover many of the observed properties of stellar bipolar outflows including the development of collimated supersonic jets.

In this paper we review the physics behind the GWBB scenario in detail and consider its strengths and weakness. Alternative models involving MHD processes are also examined. Applications of these models to each of the principle classes of stellar bipolar outflow (YSO, PNe, LBV, SN87A) are then reviewed. Outstanding issues in the study of bipolar outflows are considered as are those questions which arise when the outflows are viewed as a single class of phenomena occuring across the HR diagram.

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Multipolar bubbles and jets in low excitation planetary nebulae – Towards an understanding of the formation and shaping of planetary nebulae

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First results from a Hubble Space Telescope Wide-Field Planetary Camera 2 Hα imaging survey of young planetary nebulae (PNe) are reported. The PNe have been selected on the basis of their low excitation characteristics. All objects imaged so far show highly aspherical morphology, with a majority characterised by multipolar bubbles distributed roughly point-symmetrically around the central star. In some objects, bipolar ansae or collimated radial structures are seen, indicating the presence of jets, whereas in others bright structures near the minor axes indicate the presence of disks or torii. The complexity, organization and symmetry of the above structures leads us to propose that the primary agent for shaping PNe are high-speed collimated outflows or jets which operate during the late AGB and/or early post-AGB evolutionary phase, and not a pre-existing equatorial density enhancement as envisioned in the currently popular model. These outflows carve out a complex imprint within an intrinsically spherical AGB circumstellar envelope (CSE). Subsequent expansion of a hot, tenuous stellar wind from the post-AGB star inside the imprinted AGB CSE then produces the observed PN, whose shape and structure depend in detail on how the characteristics of the jets change with time.

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The Size and Age of Sakurai's Planetary Nebula and the Temperature of its Central Star

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We present high resolution, spatially resolved, spectra of the nebula surrounding Sakurai's object. We find the expansion velocity of the nebula to be 30.9 ± 0.7 km/s, and the nebula extent to be 44" in diameter. We discuss the wide range of reported distances to Sakurai's object and the dilemma that these present since some evidence strongly favors a short distance (1.1 kpc) while other data strongly favor a longer distance (5–8 kpc). We also present spectra of Sakurai's star centered near the λ4216 CN band that suggests the star had cooled significantly between October 1996 and May 1997, but had not cooled further by July 1997.

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CO observations and mass loss of MS- and S-stars

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We present ^{12}CO J = 1-0 and 2-1 observations of 14 S-stars, and report 6 new detections. Two stars were observed in the ^{13}CO J = 1-0 and 2-1 lines, and one tentative 2-1 detection is reported.

A compilation is presented of all CO observations of S-stars. The stars in this sample are separated into "intrinsic" and "extrinsic" S-stars, based on direct observation of the Technetium line, or infrared properties.

The dust mass loss rate per unit distance is derived from IRAS 60 μm data taking into the fact that for small mass loss rates the observed flux is an overestimate of the excess emission due to dust. The gas mass loss rate per unit distance is derived from CO data. Distances and luminosities are estimated, partly from HIPPARCOS parallax data. The largest mass loss rate derived is that for W Aql with (0.8-2.0) $\times 10^{-5}$ $M_\odot$ yr^{-1}, and the lowest is that for o Ori with $< 1.2 \times 10^{-9}$ $M_\odot$ yr^{-1}. The S-stars without Tc have smaller mass loss rates, than those with Tc.

Diagrams showing mass loss rate, dust-to-gas ratio and expansion velocity versus pulsation period are presented, and compared to similar data for carbon- and oxygen-rich Miras. The S-Miras stand not out in any way from the C- or O-Miras in these diagrams. In the diagram with expansion velocity versus pulsation period, the S-SRs span the same range in velocity as the S-Miras, but they have periods which are about a factor of 2.5 shorter. This was previously noted for O-rich SRs. As in that case, the most straightforward explanantion is that the SRs among the S-stars pulsate in a higher order pulsation mode.

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http://www.mpa-garching.mpg.de/~groen/groen.html

A sample of planetary nebulæ observed by HIPPARCOS

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By using HIPPARCOS data (magnitudes, parallaxes, proper motions), (1) we determine new values of the apparent luminosity of the central stars of 19 planetary nebulae, (2) we discuss their distance and position on the T/L diagram. By comparison with the distances determined by individual or statistical methods, we see that most of these "ground" distances look overestimated when we trust the HIPPARCOS trigonometric parallaxes. It seems that for compact nebulae, the nebula itself could influence the parallax measurement. In particular, the very small HIPPARCOS distances to SwSt 1 and Hu 2-1 are unexpected and are not trustworthy. Peculiar motions are analyzed, in terms of astrophysical parameters of the binary system A 35, and in relation with asymmetric morphology.

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On water masers in circumstellar shells

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Detection rates for 22 GHz water masers from O-rich circumstellar shells are always <100%. This can in part be understood by revisiting high angular-resolution observations of masers in OH39.7+1.5 and red supergiants. The pattern of occurrence for water masers around the pulsation cycle of OH39.7+1.5 suggests that a detectable maser only occurs when it is triggered by a density enhancement with a suitable gain orientation to our line of sight. Enhancements in effect break the local symmetry of many otherwise equivalent gain paths, to provide a means for focusing emission into a narrow range of rays, which promotes a detectable maser. A brief review of masers in the circumstellar shells of red supergiants shows that water masers exhibit a rich ellipsoidal distribution of emission hot spots. Nevertheless these usually contain no water masers on the axis of their biconical, higher-velocity, lower-density, bipolar flows. If many Mira variables and OH/IR stars have important bipolar flows, some will be seen nearly pole-on, and these are less likely to exhibit water masers, even if they host OH masers.

The main input of energy (and momentum) to gas in a circumstellar shell comes from friction with dust particles driven through it by radiation pressure. In consequence the switch between radial-gain masers in OH39.7+1.5 that predominate near maximum light, and a tangential-gain maser that can occur near minimum, may result entirely from the pulsation-dependent temperature modulation of the shell. However, the fast polar wind in red supergiants is already well developed in the water masing zone, so its causality is probably located within the star itself.

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Messages

Dear Everyone,

I am preparing a review talk for the AGB Symposium at Montpellier. This review is devoted to asymmetries which are observed (or even modelled) in the images of Miras, AGB and post-AGB stars (at any wavelength of observation) and their circumstellar environment.

May I ask you please to send me one relevant result you have obtained in this field : any comments/reprints/figures/references may be very welcome for my task. I will appreciate any material and short information as comments on your relevant recent result with one or two figures.

Best regards, Bruno.

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