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Abstract of recently accepted papers

Dust and the spectral energy distribution of the OH/IR star OH 127.8+0.0: Evidence for circumstellar metallic iron

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We present a fit to the spectral energy distribution of OH 127.8+0.0, a typical asymptotic giant branch star with an optically thick circumstellar dust shell. The fit to the dust spectrum is achieved using non-spherical grains consisting of metallic iron, amorphous and crystalline silicates and water ice. Previous similar attempts have not resulted in a satisfactory fit to the observed spectral energy distributions, mainly because of an apparent lack of opacity in the 3–8 μm region of the spectrum. Non-spherical metallic iron grains provide an identification for the missing source of opacity in the near-infrared. Using the derived dust composition, we have calculated spectra for a range of mass-loss rates in order to perform a consistency check by comparison with other evolved stars. The $L - [12\ \mu\mathrm{m}]$ colours of these models correctly predict the mass-loss rate of a sample of AGB stars, strengthening our conclusion that the metallic iron grains dominate the near-infrared flux. We discuss a formation mechanism for non-spherical metallic iron grains.

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Structure, Evolution and Nucleosynthesis of Primordial Stars

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The evolution of population III stars ($Z = 0$) is followed from the pre-main sequence phase up to the AGB phase for intermediate-mass stars and up to C ignition in more massive stars. Our grid includes 11 stars, covering the mass range 0.8 to $20 M_\odot$. During the H and He core burning phases an overshooting characterized by $d = 0.20 H_P$ was applied and during the AGB phase a small extension of the convective envelope was also allowed, characterized by $d = 0.05 H_P$. We find that at the beginning of the AGB phase, following the development of a convective instability in the He burning shell, a secondary convective zone forms at the He-H discontinuity. This unusual convective zone then expands and overlaps with the region previously occupied by the receding He-driven instability. Carbon in engulfed and a H flash takes place due to the activation of the CNO cycle. Following these successive (H+He) flashes, the convective envelope penetrates deeper into the star, reaches the secondary H convective shell and allows CNO catalysts to be dredged up to the surface. These mixing episodes, which have been found to occur in our 1, 1.5, 2, 3, 4 and $5 M_\odot$ models, increase the carbon abundance in the envelope and allows low- and intermediate-mass stars to achieve a "standard" thermally pulsing AGB phase, confirming the recent results by Chieffi et al. (2001). We also find that at the beginning of the double shell burning evolution, our 4 and $5 M_\odot$ models experience so called "degenerate" thermal pulses, which are very similar to those found by Frost et al. (1998), but absent from Chieffi et al. (2001) simulations. Finally, in the $7 M_\odot$ model, the CNO envelope abundance following the second dredge-up is so large that the star does not experience the carbon injection episode and follows a standard thermally pulsing AGB evolution. Our computations also indicate that, thanks to the small overshooting at the base of the convective envelope, the third dredge-up is already operating in stars with $M \geq 1.5 M_\odot$ after a few pulses, and that by the end of our modeling, hot bottom burning is activated in stars more massive than $\sim 2 M_\odot$. This evolutionary behavior suggests that primordial low- and intermediate stars could have been significant contributors to the production of primary ^{12}C, ^{14}N, and may have contributed to some extent to the production of Mg and Al and possibly s-elements (despite the lack of iron seeds) in the early universe.

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The time variation in infrared water-vapour bands in Mira variables

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The time variation in the water-vapour bands in oxygen-rich Mira variables has been investigated using multi-epoch ISO/SWS spectra of four Mira variables in the 2.5–4.0 μm region. All four stars show H_2O bands in absorption around minimum in the visual light curve. At maximum, H_2O emission features appear in the ~3.5–4.0 μm region, while the features at shorter wavelengths remain in absorption. These H_2O bands in the 2.5–4.0 μm region originate from the extended atmosphere.

The analysis has been carried out with a disk shape, slab geometry model. The observed H_2O bands are reproduced by two layers; a 'hot' layer with an excitation temperature of 2000 K and a 'cool' layer with an excitation temperature of 1000–1400 K. The column densities of the 'hot' layer are 6×10^{20}–3×10^{22} cm^{-2}, and exceed 3×10^{21} cm^{-2} when the features are observed in emission. The radii of the 'hot' layer ($R_{\rm hot}$) are $\sim 1 R_*$ at visual minimum and $2 R_*$ at maximum, where R_* is a radius of background source of the model, in practical, the radius of a 3000 K black body. The 'cool' layer has the column density ($N_{\rm cool}$) of 7×10^{20}–5×10^{22} cm^{-2}, and is located at 2.5–4.0 R_*. $N_{\rm cool}$ depends on the object rather than the variability phase. The time variation of $R_{\rm hot}/R_*$ from 1 to 2 is attributed to the actual variation in the radius of the H_2O layer, since the variation in $R_{\rm hot}$ far exceeds the variation in the 'continuum' stellar radius. A high H_2O density shell occurs near the surface of the star around minimum, and moves out with the stellar pulsation. This shell gradually fades away

after maximum, and a new high H_2O density shell is formed in the inner region again at the next minimum. Due to large optical depth of H_2O, the near-infrared variability is dominated by the H_2O layer, and the L'-band flux correlates with the area of the H_2O shell. The infrared molecular bands trace the structure of the extended atmosphere and impose appreciable effects on near-infrared light curve of Mira variables.

Accepted by A&A *Preprints can be obtained by contacting Matsuura (m.matsuura@umist.ac.uk) or via WWW on either http://saturn.phy.umist.ac.uk:8000/~tjm/2001/2001.html or http://arXiv.org/abs/astro-ph/0201084*

PN and galactic chemical evolution

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Recent applications of PN to the study of galactic chemical evolution are reviewed, such as PN and stellar populations, abundance gradients, including their space and time variations, determination of the He/H radial gradient and of the helium-to-metals enrichment ratio, and the [O/Fe] × [Fe/H] relation in the solar neighbourhood and in the galactic bulge.

IAU Symposium 209, Planetary Nebulae and Their Role in the Universe, R. Sutherland, S. Kwok, M. Dopita, eds., in press 2002

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CO 1^{st} overtone spectra of cool evolved stars: Diagnostics for hydrodynamic atmosphere models

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We present spectra covering the wavelength range 2.28 to 2.36 μm at a resolution of $\Delta\lambda = 0.0007$ μm (or R = 3500) for a sample of 24 cool evolved stars. The sample comprises 8 M supergiants, 5 M giants, 3 S stars, 6 carbon stars, and 2 RV Tauri variables. The wavelengths covered include the main parts of the $^{12}C^{16}O$ v=2–0 and 3–1 overtone bands, as well as the v=4–2 and ^{13}CO v=2–0 bandhead regions. CO lines dominate the spectrum for all the stars observed, and at this resolution most of the observed features can be identified with individual CO R- or P-branch lines or blends. The observed transitions arise from a wide range of energy levels extending from the ground state to $E/k > 20{,}000$ K. We looked for correlations between the intensities of various CO absorption line features and with other stellar properties, including IR colors and mass loss rates. Two useful CO line features are the v=2–0 R14 line, and the CO v=2–0 bandhead. The intensity of the 2–0 bandhead shows a trend with K-[12] color such that the reddest stars (K-[12] > 3 mag) exhibit a wide range in 2–0 bandhead depth, while the least reddened have the deepest 2–0 bandheads, with a small range of variation from star to star. Gas mass loss rates for both the AGB stars and the red supergiants in our sample correlate with the K-[12] color, consistent with other studies. The data imply that stars with $\dot{M}_{\rm gas} < 5 \times 10^{-7}$ $M_\odot$ y^{-1} exhibit a much narrower range in the relative strengths of CO 2–0 band features than stars with higher mass loss rates. The range in observed spectral properties implies that there are significant differences in atmospheric structure among the stars in this sample.

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Preprints can be obtained by contacting jbieging@as.arizona.edu
or via WWW on URL http://sirius.as.arizona.edu/~jbieging/CO_paper.ps

An improved mass-loss description for dust-driven superwinds and tip-AGB evolution models

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We derive an improved description of dust-driven stellar mass-loss for the cool winds of carbon-rich tip-AGB stars. We use pulsating wind models in which the mass loss is driven by radiation pressure on dust grains, for C-rich chemistry. From a larger set of these models, selected for representative dynamical (pulsational velocity amplitude Δv, period P) and chemical (the ϵ_C/ϵ_O abundance ratio) input parameters, an improved approximative mass-loss formula has been derived which depends only on the stellar parameters (effective temperature $T_{\rm eff}$, luminosity L and mass M). Due to the detailed consideration of the chemistry and the physics of the dust nucleation and growth processes, there is a particularly strong dependence of the mass-loss rate $\dot{M}$ (in $M_\odot$/yr) on $T_{\rm eff}$: $\log \dot{M} = 8.86 - 1.95 \cdot \log M/M_\odot - 6.81 \cdot \log T/K + 2.47 \cdot \log L/L_\odot$. The dependence of the model mass-loss on the pulsational period has explicitly been accounted for in connection with the luminosity dependence, by applying an observed period–luminosity relation for C-rich Miras. We also apply the improved mass-loss description to our evolution models, and we revisit their tip-AGB mass-loss histories and the total masses lost, in comparison to our earlier work with a preliminary mass-loss description. While there is virtually no difference for the models in the lower mass range of consideration ($M_i = 1.0$ to $\approx 1.3\,M_\odot$), we now find more realistic, larger superwind mass-loss rates for larger stellar masses: i.e., $\dot{M}$ between ≈ 0.4 and $1.0 \cdot 10^{-4}$ $M_\odot$/yr for M_i between 1.85 and 2.65 $M_\odot$, removing between 0.6 and 1.2 $M_\odot$, respectively, during the final 30 000 yrs on the tip-AGB.

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Submilliarcsecond-resolution mapping of the 43GHz SiO maser emission in the bipolar post-AGB nebula OH231.8+4.2

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We present $\sim$0.3 milliarcsec-resolution maps of the SiO (v=2, J=1–0) maser emission in the bipolar post-AGB nebula OH 231.8+4.2 obtained with the Very Long Baseline Array. These observations have provided for the first time the structure and kinematics of the close stellar environment in a proto-Planetary Nebula. Our observations reveal the SiO maser emission arising in several bright spots of less than $\sim 10^{13}$ cm in size forming a structure elongated in the direction perpendicular to the symmetry axis of the nebula. Such a distribution is consistent with an equatorial torus with a radius of $\sim$6 AU around the central star. A complex velocity gradient is found along the torus, which suggests rotation and infall of material towards the star. The rotation and infalling velocities deduced are of the same order and range between $\sim$7 and $\sim$10 km s^{-1}. From our data, we estimate the mass of the SiO torus and the central star, as well as a stringent upper limit to the present stellar mass-loss rate.

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Time-dependent asymmetries in the atmosphere of the Mira variable R Tri through IR interferometry

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We report high-resolution (< 0.05 mas) angular size measurements of the Mira variable star R Triangulum using the Palomar Testbed Interferometer (PTI). Observations were conducted in the K band (2.0-2.4 μm) between the visual phases of 0.77–0.88, and one period later at phase 0.91. The spatial coverage of the measurements spans 40 degrees in position angle. Three simple geometries were modeled: a uniform ellipse model and a uniform sphere with a brighter "disk" model have lower χ^2_μ than the uniform spherical disk model by factors of 5–10. For the non-spherically symmetric models, the axis of symmetry is clustered between 20 and 35 degrees. The position angles are roughly perpendicular to visual polarization position angles, which supports a non-spherically symmetric source of light scattering. For the elliptical geometry, averaging the semi-major and semi-minor axes throughout the dataset yield an ensemble average angular diameter of 5.22 ± 0.30 mas; the ensemble average axial ratio of $(2a/2b) = 0.75$ is similar to that previously determined for other Mira and semi-regular variable stars.

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Infrared Space Observatory Polarimetric Imaging of the Egg Nebula (RAFGL 2688)

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We present polarimetric imaging of the protoplanetary nebula RAFGL 2688 obtained at 4.5 μm with the Infrared Space Observatory (ISO). We have deconvolved the images to remove the signature of the point spread function of the ISO telescope, to the extent possible. The deconvolved 4.5 μm image and polarimetric map reveal a bright point source with faint, surrounding reflection nebulosity. The reflection nebula is brightest to the north-northeast, in agreement with previous ground- and space-based infrared imaging. Comparison with previous near-infrared polarimetric imaging suggests that the polarization of starlight induced by the dust grains in RAFGL 2688 is more or less independent of wavelength between 2 μm and 4.5 μm. This, in turn, indicates that scattering dominates over thermal emission at wavelengths as long as ~ 5 μm, and that the dust grains have characteristic radii < 1 μm.

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or via WWW on http://xxx.lanl.gov/archive/astro-ph (astro-ph/0202034)

X-ray emission from central binary systems of planetary nebulae

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We study the conditions under which a main sequence binary companion to the central ionizing star of a planetary nebula (PN) might become magnetically active and thereby display strong X-ray luminosity, $L_x \gtrsim 5 \times 10^{29} erg\ s^{-1}$. Since most PNe are older than few billion years, any main sequence companion will rotate too slowly to have magnetic activity and hence bright X-ray emission, unless it is spun-up. We demonstrate that if the orbital separation during the asymptotic giant branch (AGB) phase of the PN progenitor is $a \lesssim 30 - 60AU$, main sequence companions in the spectral type range F7 to M4 (mass range $0.3M_\odot \lesssim M_2 \lesssim 1.3M_\odot$) will accrete enough angular momentum from the AGB wind to rotate rapidly, become magnetically active, and exhibit X-ray luminosities $L_x \gtrsim 5 \times 10^{29} erg\ s^{-1}$. Lower mass M stars and brown dwarfs can also become magnetically active, but they should have small orbital separations and hence are less likely to survive the AGB phase of the progenitor. For orbital separation of $a \lesssim 0.3AU$, i.e., for a binary systems that went through a common envelope phase, the fast wind from the central WD star will interact with (and potentially disrupt) the companion's corona on the side facing the central star, while for $a \lesssim 6R_\odot$, i.e., an orbital period of $P_{\rm orb} \lesssim 30$ hours, the WD's fast wind will compress a dense small region near the surface of the companion. This region may thermally emit X-rays with nonnegligible luminosity. We estimate that $20 - 30\%$ of elliptical PNe and $30 - 50\%$ of bipolar PNe are likely to have magnetically active companions which will reveal themselves in X-ray observations. Re-analysis of Chandra X-ray Observatory spectroscopy of the compact central source of NGC 7293 indicates that the emitting region of this object possesses abundance anomalies similar to those of coronally active main-sequence stars. High-resolution X-ray spectroscopy of this and other compact sources in PNe are necessary to confirm a coronal origin for the X-ray emission.

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or via WWW on http://xxx.lanl.gov/archive/astro-ph (astro-ph/0111266)

The identification of SS73 71 as a new symbiotic star

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We report spectroscopic observations of a new symbiotic star. This star is located in our Galaxy in the direction of the bulge and was discovered during a southern spectroscopic survey of Hα emission line objects. The star, SS73 71, after Sanduleak & Stephenson (1973), shows characteristics of a symbiotic star : the presence of TiO bands and emission lines of ions of higher ionization such as He II4686Å and [O III]5007Å. Here, we present some of the main spectroscopic features, line intensities and, whenever possible, some physical parameters.

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MHD Models of Planetary Nebulae: Review

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Hydrodynamical (HD) simulations played an important role in understanding the dynamics and shaping of Planetary Nebulae (PNe) in the past century. However, HD solutions are just a first order approach. The new millennium arrives with the generalized understanding that the effects of magnetic fields (i.e., MHD) are necessary to study the dynamics of PNe. Thus, B-fields introduce a whole new number of physical possibilities for the modeling. We here review recent advances in MHD modeling of PNe.

IAU Symposym 209, Planetary Nebulae: Their Evolution and Role in the Universe, ASP Conference Series 2002, eds. M. Dopita, S. Kwok, in press

Preprints can be obtained by www http://arXiv.org/abs/astro-ph/0202041

The dynamical evolution of the circumstellar gas around low-and intermediate-mass stars I: the AGB

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We have investigated the dynamical interaction of low- and-intermediate mass stars (from 1 to 5 $M_{\odot}$) with their interstellar medium (ISM). In this first paper, we examine the structures generated by the stellar winds during the Asymptotic Giant Branch (AGB) phase, using a numerical code and the wind history predicted by stellar evolution. The influence of the external ISM is also taken into account.

We find that the wind variations associated with the thermal pulses lead to the formation of transient shells with an average lifetime of $\sim 20,000$ yr, and consequently do not remain recorded in the density or velocity structure of the gas. The formation of shells that survive at the end of the AGB occurs via two main processes: shocks between the shells formed by two consecutive enhancements of the mass-loss or via continuous accumulation of the material ejected by the star in the interaction region with the ISM.

Our models show that the mass of the circumstellar envelope increases appreciably due to the ISM material swept up by the wind (up to ~ 70 % for the 1 $_{\odot}$ stellar model). We also point out the importance of the ISM on the deceleration and compression of the external shells.

According to our simulations, large regions (up to 2.5 pc) of neutral gas surrounding the molecular envelopes of AGB stars are expected. These large regions of gas are formed from the mass-loss experienced by the star during the AGB evolution.

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Preprints can be obtained by contacting villaver@stsci.edu

Also available from the URL http://arXiv.org/abs/astro-ph/0202050

Rapidly-rotating Lithium-rich K Giants: the New Case of the Giant PDS 365

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PDS 365 is a newly detected rapidly rotating ($v \sin i\ =\ 20\,\mathrm{km\,s^{-1}}$) single low mass giant star which with HD 233517 and HD 219025 forms a remarkable ensemble of single K giants with the unique properties of rapid rotation, very strong Li lines, an asymmetrical Hα profile, and a large far infrared excess. Their $v \sin i$ values are between 18 and 23 $\mathrm{km\,s^{-1}}$, and LTE Li abundances, $\log \varepsilon$(Li), are between 2.9 and 3.9. Detailed analysis of PDS 365 reveals it to be a $\sim 1 M_{\odot}$ giant with a value of $^{12}\mathrm{C}/^{13}\mathrm{C}$ approximately equal to 12. A clear relation between high rotational velocities and very high Li abundances for K giant stars is found only when asymmetrical Hα profiles and large far-infrared excesses are present. If we consider single K giants, we find that among rapid ($v \sin i \geq 8\,\mathrm{km\ s^{-1}}$) rotators, a very large proportion ($\sim$ 50%) are Li-rich giants. This proportion is in contrast with a very low proportion ($\sim$ 2%) of Li-rich stars among the much more common slowly rotating K giants. This striking difference is discussed in terms of proposed mechanisms for Li enrichment.

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Preprints can be obtained by contacting drake@on.br

Imaging and Spatially Resolved Spectroscopy of AFGL 2688 in the Thermal Infrared Region

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We present ground-based high-resolution (~0".3) imaging of AFGL 2688 at L' (3.8 μm) and M' (4.7 μm). A wealth of structure in the central region is revealed due to less extinction in the thermal infrared. A clear border in the southern lobe at L' corresponds to the edge of the heavily obscured region in visible, indicating there is a dense material surrounding the central region. The images also show a narrow dark lane oriented to 140° east of north with the normal at 50°. The normal position angle is inconsistent with the optical polar axis (PA = 15°), but is aligned to the high-velocity CO components found in the radio wavelength observations. The central star remains invisible at L' and M'. Several clumpy regions in the north lobe dominate in L' and M' luminosity. In particular a pointlike source (peak A) at 0".5 northeast of the center of the nebula exhibits the highest surface brightness with a very red spectral energy distribution (SED). Based on the almost identical SED as adjacent regions, we suggest that the pointlike source is not self-luminous, as was proposed, but is a dense dusty blob reflecting thermal emission from the central star.

We also present spatially resolved slit spectroscopy of the bright dusty blobs. An emission feature at 3.4 μm as well as at 3.3 μm is detected everywhere within our field of view. There is no spatial variation in the infrared emission feature (IEF) throughout the observed area (0".2–1".5, or 240–1800 AU from the central source). The constant flux ratio of the emission feature relative to the continuum is consistent with the view that the blobs are mostly reflecting the light from the central star in the 3 μm region.

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