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Abstract of recently accepted papers

The structure and dynamics of the molecular envelope of M 2−56

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M 2−56 is a protoplanetary nebula (PPN) in which strong shocks are taking place, therefore, useful to study the post−AGB wind interaction. It is well known that molecular observations allow studying the mass distribution of PPNe, even in those regions that have been recently shocked. We present high−resolution maps of the emission of ^{12}CO $J = 2-1$ and $J = 1-0$ in M 2−56. Such maps show a bipolar, molecular nebula that extends $\sim 28''$ along the symmetry axis. The nebula is composed of two contiguous, incomplete shells located along the symmetry axis, which has an inclination of $\sim 17^{o}$ with respect to the plane of the sky. Those empty lobes intersect in the center of the nebula, where there is a small and dense ring perpendicular to the axis. This central ring expands radially at about 8 km s^{-1} and seems to be the remnant of the circumstellar envelope of the AGB star, that has not been accelerated by the interaction with the fast post−AGB jets. The radius of the central ring is of $\sim 4\,10^{16}$ cm, for a distance of 2.1 kpc (deduced from an analysis of the main properties of the object). At $\sim 4\,10^{17}$ cm from the nebular center, the tips of the lobes reach axial expansion velocities of ~ 200 km s^{-1}. We have developed a model for the spatio−kinematical distribution and the excitation conditions of the molecular gas in M 2−56. From the best fitting of the observations with the predictions of the model for both lines, we have estimated the physical conditions of the molecular nebula. It is found that the density varies from $5\,10^{3}$ to $0.6\,10^{3}$ cm^{-3} from the nebular center to the lobe tips, and that the part of the lobes that has not been detected is probably composed of photodissociated gas, due to the effect of interstellar photons on low−density regions. The rotational temperature is estimated to be approximately constant, $\sim 13-16$ K. For the assumed geometry, a velocity field composed by a dominant radial component plus an axial contribution has been deduced. The emission of both lines is found to be optically thin, and therefore probes the whole molecular gas, which has a mass of $\sim 0.05\,M_{\odot}$. The 'scalar' momentum and the kinetic energy of the different regions of the molecular nebula have been calculated, finding that the high momentum won by the gas in the post−AGB phase cannot have been supplied by the radiation pressure mechanism. Although the central star of M 2−56 is not very hot yet (~ 20000 K), this PPN has a large kinematical age, between 1000 yr and 1700 yr, in comparison with other PPNe that have hotter central stars. M 2−56 may not be a typical PPN, but an intermediate object between the known low−mass post−AGB nebulae and the standard PPNe.

Accepted by A&A

Preprints can be obtained by contacting carrizo@oan.es
or via WWW on http://www.oan.es/preprints/

Bispectrum speckle interferometry of the Red Rectangle: diffraction-limited near-infrared images reconstructed from Keck telescope speckle data

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We present new near-infrared (2.1–3.3 μm) images of the Red Rectangle with unprecedented diffraction-limited angular resolutions of 46–68 mas; 4 times higher than that of the Hubble space telescope and almost a factor of two improvement over the previous 6 m SAO telecope speckle images presented by Men'shchikov et al. (1998). The new images, which were reconstructed from Keck telescope speckle data using the bispectrum speckle interferometry method, clearly show two bright lobes above and below the optically thick dark lane obscuring the central binary. X-shaped spikes, thought to trace the surface of a biconical flow, change the intensity distribution of the bright lobes, making them appear broadened or with an east-west double-peak in images with the highest resolution. The striking biconical appearance of the Red Rectangle is preserved on scales from 50 mas to 1′ and from the visible (red) to at least 10 μm, implying that large grains of at least several microns in size dominate scattering. The new images supplement previous 76 mas resolution speckle reconstructions at shorter wavelengths of 0.6–0.8 μm (Osterbart et al. 1997) and 0.7–2.2 μm (Men'shchikov et al. 1998), allowing a more detailed analysis of the famous bipolar nebula. The intensity distribution of the images is inconsistent with a flat disk geometry frequently used to model the bipolar nebulae. Instead, a geometrically thick torus-like density distribution with bipolar conical cavities is preferred. The extent of the bright lobes indicates that the dense torus has a diameter of ∼100 AU, for an assumed distance of 330 pc. This torus may be the outer reaches of a flared thick disk tapering inwards to the central star, however such a density enhancement on the midplane is not strictly required to explain the narrow dark lane obscuring the central stars.

Accepted by Astronomy & Astrophysics *Preprints can be obtained by contacting* sasha@mpifr-bonn.mpg.de

The Formation and Evolution of Planetary Nebulae

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We review our present knowledge about the formation and evolution of planetary nebulae and discuss the relevant processes responsible in creating and shaping planetary nebulae out of a cool AGB wind envelope. Based on 1D simulations we show that a hydrodynamical treatment along the upper AGB leads quite naturally to more realistic starting configurations for planetaries with density slopes steeper than r^{-2}. Taking into account photoionization and wind interaction in a realistic manner, the hydrodynamics of post-AGB wind envelopes leads to density structures and velocity fields in close resemblance to observations of spherical or elliptical planetary nebulae.

Invited Review, IAU Symposium 209 "Planetary Nebulae. Their Evolution and Role in the Universe" (in press)
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or via WWW on
http://www.aip.de/groups/sternphysik/stp/publications.html#Pub_2002

Structure and Evolution of PN Haloes

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The density structure of the extended haloes of Planetary Nebulae (PN) is generally believed to reflect the previous history of heavy mass loss during the final stages of stellar evolution on the asymptotic giant-branch (AGB). In this review, we discuss different interpretations of the observed PN halo structures in the light of recent numerical simulations combining detailed AGB and post-AGB stellar evolution calculations with time-dependent hydrodynamical wind models.

Invited Review, IAU Symposium 209 "Planetary Nebulae. Their Evolution and Role in the Universe" (in press)

Preprints can be obtained by contacting msteffen@aip.de
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RU Cen and SX Cen : two strongly depleted RV Tauri stars in binary systems. The RV Tauri photometric b phenomenon and binarity.

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We present a chemical abundance analysis on the basis of high signal-to-noise and high-resolution ($\lambda/\Delta\lambda \sim 48000$) optical spectra of two RV Tauri stars RU Cen and SX Cen. With an [Fe/H] $= -1.9$ and a [Zn/Fe] $= +0.9$ for RU Cen and a [Fe/H] $= -1.1$ and a [Zn/Fe] $= +0.6$ for SX Cen, both stars of spectroscopic class B display strong depletion of refractory elements in their photospheres. Our CORALIE radial velocity measurements prove the stars to be members of binary systems and a detailed construction of the spectral energy distribution indicate the presence of a large amount of hot circumstellar dust. Moreover, the orbital period of SX Cen of around 600 days is similar to the published period of mean magnitude variation in the light curve (RV Tauri phomometric class b phenomenon). All these observations indicate the presence of a stable circumbinary disk in the objects and strengthen the model that this is a necessary condition for the depletion process to take place.

Accepted by A&A.

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The s-process in post-AGB stars

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In this contribution an overview is given of recent accurate chemical abundance studies in post-AGB stars. The intrinsic nature of the enrichement and the spread in metallicity together with the absence of strong molecular

veiling make post-AGB stars very useful to constrain AGB (chemical) evolutionary models. S-process enrichment is, however, not a general characteristic of post-AGB stars and a photospheric chemical study is not always a good tracer for the evolved status of an object.

invited review. IAU Symp. 209. Planetary Nebulae, Their evolution and role in the Universe, in press.

Preprints can be obtained by contacting Hans.VanWinckel@ster.kuleuven.ac.be
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The 3 μm Spectrum of R Doradus Observed with the ISO-SWS

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We have modeled the 2.6–3.7 μm spectrum of the red semiregular variable R Doradus observed with the Short-Wavelength Spectrometer on board the Infrared Space Observatory. The wavelength resolution of the observations varies between R $\sim$ 2000–2500. We have calculated a synthetic spectrum using a hydrostatic model photosphere in spherical geometry. The agreement between the synthetic spectrum and the ISO observations is encouraging, especially in the wavelength region of 2.8–3.7 μm, suggesting that a hydrostatic model photosphere is adequate for the calculation of synthetic spectra in the near infrared for this moderately varying red giant star. However, an additional absorption component is needed at 2.6–2.8 μm and this discrepancy is discussed. The spectral signatures are dominated by water vapour in the stellar photosphere, but several photospheric OH, CO, and SiO features are also present. The effective temperature and surface gravity derived for R Dor, based on the 2.6–3.7 μm ISO spectrum and the modeling of it with a hydrostatic model photosphere, are 3000 ± 100 K and $\log g = 0 \pm 1$ (cgs), respectively. The spectral region observed is found to be temperature sensitive. The effective temperature given here is slightly higher than those reported in the literature. We also discuss possible reasons for this.

Accepted by A&A

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The extreme Type I planetary nebula M2-52

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High-resolution spectrophotometric data of the central zone of the Br-type planetary nebula M2-52 are presented. The nebula has a rich spectrum, with high and low excitation lines. The chemical composition derived from the spectra shows that He and N are very enhanced in M2-52. Thus, this object can be classified as an extreme Peimbert's Type I PN. The chemical composition of the ionized gas is: He/H = 0.165±0.010, O/H = (2.6±0.5)×10^{-4}, N/O = 2.3±0.3, Ne/O = 0.37±0.10, Ar/O = (9.2±2.0)×10^{-3} and S/O >2.0×10^{-3}. The expansion velocity of the nebula is, on average, about 20 ± 2 km s^{-1}, but the low ionization species (N^+ and S^+) seem to show systematically slightly lower expansion velocities (18 km s^{-1}) than O^{++} and He^+ which have v_{exp} = 20 km s^{-1} while H^+ and He^{++} present $v_{exp} \sim 22$ km s^{-1}. This behavior could indicate that the outer zones of the ionized gas are being decelerated by the molecular ring located around the central star.

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Preprints can be obtained by contacting miriam@astroscu.unam.mx
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or via anonymous ftp on ftp.astroscu.unam.mx, directory pub/temporal/miriam/m2-52.ps

The Local Group Census: planetary nebulae in Sextans B

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Five planetary nebulae (PNe) have been discovered in the nearby dwarf irregular galaxy. Emission line images were obtained using the Wide Field Camera of the 2.5m Isaac Newton Telescope (INT) at La Palma (Spain). The candidate PNe were identified by their point-like appearance and relatively strong [O III] emission-line fluxes. They are located within a galactocentric distance of 2.8 arcmin, corresponding to 1.1 kpc at the distance of Sextans B. Luminosities are in the range 1800–5600 $L_{\odot}$. Sextans B is one of the smallest dwarf irregular galaxies with a PN population. The number of PNe detected suggest an enhanced star formation rate between 1 and 5 Gyr ago.

Accepted by Astronomy & Astrophysics

Preprints can be obtained from astro-ph/0202516 or contacting laura@arcetri.astro.it

A wall of dust around a proto-Mira

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We present the discovery of a huge ($19' \times 16'$) dust ring surrounding a bright ($V = 10.60$) red star. The dust ring has, at $D = 700$ pc, a diameter of 4 pc, and a central hole of ~1.5 pc across. Part of the shell is also seen as an absorption nebulosity. The star is classified as a M3III AGB star. Among AGB stars its detached shell is of unrivalled size. Detached shells around AGB stars are normally interpreted in terms of thermal pulses. However, in this case a significant fraction of the shell may consist of swept-up ISM; the detached appearance can be explained with wind–ISM interaction. We present a model where the AGB wind has been stopped by the surrounding ISM, and the swept-up shell is now expanding at the sound speed. The model predicts that the ring will disperse over a few times 10^5 yr, and eventually will leave a large hole in the ISM surrounding the AGB star or its future planetary nebula.

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Preprints can be obtained by contacting a.zijlstra@umist.ac.uk
or via WWW on http://iapetus.phy.umist.ac.uk/DetRing/DetRing.html

The evolution of the Mira variable R Hydrae

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The Mira variable R Hydrae is well known for its declining period, which Wood & Zarro (1981) attributed to a possible recent thermal pulse. Here we investigate the long-term period evolution, covering 340 years, going back to its discovery in AD 1662. The data includes photometric monitoring by amateur and other astronomers over the last century, and recorded dates of maximum for earlier times. Wavelets are used to determine both the period and semi-amplitude. We show that the period decreased linearly between 1770 and 1950; since 1950 the period has stabilized at 385 days. The semi-amplitude is shown to closely follow the period evolution. Analysis of the oldest data shows that before 1770 the period was about 495 days. We find no evidence for an increasing period during this time as found by Wood & Zarro. We discuss the mass-loss history of R Hya: the IRAS data shows that the mass loss dropped dramatically around AD 1750. The evolution of the mass loss as function of period agrees with the mass-loss formalism from Vassiliadis & Wood; it is much larger than predicted by the Blöcker law. An outer detached IRAS shell suggests that R Hya has experienced mass-loss interruptions before. The period evolution can be explained by two models: a thermal pulse occuring around AD 1600, or an non-linear instability leading to an internal relaxation of the stellar structure. The elapsed time between the mass-loss decline giving rise to the outer detached shell, and the recent event, of approximately 5000 yr suggests that only one of these events could be due to a thermal pulse. Further monitoring of R Hya is recommended, as both models make strong predictions for the future period evolution. We argue that R Hya-type events could provide part of the explanation for the rings seen around some AGB and post-AGB stars. Changes in Mira properties were already known on a cycle-to-cycle basis, and on the thermal-pulse time scale of $\sim 10^4$ yr. R Hya shows that significant evolution can also occur on intermediate time scales of order 10^2–10^3 yr.

Accepted by the MNRAS

Preprints can be obtained by contacting `a.zijlstra@umist.ac.uk` *or via WWW on*

`http://iapetus.phy.umist.ac.uk/R_Hya/R_Hya.html`

Diffuse X-ray emission from the planetary nebula NGC 7009

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XMM-Newton EPIC observations of the planetary nebula (PN) NGC 7009, the Saturn Nebula, have detected extended X-ray emission in its central cavity. The diffuse X-ray emission must originate in the shocked fast stellar wind. The spectra show that the temperature of the hot gas is 1.8×10^6 K. The rms density derived from the volume emission measure is a few tens H-atom cm^{-3}. The hot gas does not appear over-pressurized with respect to the nebular shell. NGC 7009 represents an evolutionary stage at which the influence of the hot gas in the PN interior starts to decline due to the diminishing strength of the fast stellar wind and the expansion of the central cavity.

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Preprints can be obtained by contacting mar@astro.uiuc.edu *or via WWW on* http://xxx.lanl.gov/abs/astro-ph/0203049

ROSAT observations of X-ray emission from planetary nebulae

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The interior of a planetary nebula (PN) is expected to be filled with shocked fast wind from the central star. This hot gas plays the most important role in the dynamical evolution of the PN; however, its physical conditions are not well-known because useful X-ray and far-UV observations were not available until the advent of *Chandra*, *XMM-Newton*, and *FUSE*. This paper reviews X-ray observations of the hot gas in PN interiors and far-UV observations of the interfaces between the hot gas and the dense nebular shells.

Invited review, IAU Symposium No. 209, Planetary Nebulae: Their Evolution and Role in the Universe (Canberra, Australia, November 19-23 2001)

Preprints can be obtained by contacting mar@astro.uiuc.edu *or via WWW on* http://xxx.lanl.gov/abs/astro-ph/0202509

PROTO-PLANETARY NEBULAE (Invited Review)

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The study of proto-planetary nebulae (PPNs) leads to a better understanding of both the preceding asymptotic giant branch stellar evolution. lanetary nebula phases of Recent results are reviewed, emphasizing the properties of the central stars and the shape and chemistry of the nebulae. The study of PPNs is seen to be important in its own right.

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

Preprints can be obtained by contacting bruce.hrivnak@valpo.edu
WWW *or via anonnymous ftp on* ftp://nebulae.valpo.edu/pub/preprints/pnconf/ppn-review.pdf

VLT/UVES and WHT/UES absorption spectroscopy of the circumstellar envelope of IRC +10° 216 using background stars: First results and a search for DIBs

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A unique and novel set of observations has been undertaken to probe the circumstellar envelope (CSE) of the nearby (130 pc) carbon star IRC + 10°216 using optical absorption spectroscopy towards *background stars* lying beyond the envelope. The primary aim of the observations is to search for diffuse band (DIB) carriers in the CSE, for which the mass-losing envelopes of carbon stars are a likely place of origin. Our principal

target is a V=16 G-type star located 37" from IRC +10°216 and was observed with VLT/UVES. A detailed model atmosphere and abundance analysis shows that it is somewhat metal-poor and has confirmed that it lies far beyond IRC +10°216. The *circumstellar* H+2H_2 column density expected along the line of sight towards this target is relatively high, $\sim 2\times10^{21}$ cm^{-2}, and is large compared to that derived from the small *interstellar* extinction estimated in the zone of IRC +10°,216 at b=+43°, $E_{B-V} < 0.03$ mag. The CSE is certainly detected in the K I resonance lines, which are centred at the heliocentric velocity of IRC +10°,216 and have FWHM $\sim$ 30 km s^{-1}, consistent with twice the terminal expansion velocity of the circumstellar gas. The data show also that circumstellar Na I is very probably detected, as seen towards two background stars. The strongest DIB (6284 Å) present in the UVES wavelength coverage is detected but very probably arises in the foreground ISM. No DIB is detected at 6614 Å, or elsewhere. Overall, the data suggest that the DIB carriers, if present in the CSE, have a low abundance relative to H in the C-rich envelope of IRC +10°216, in comparison with this ratio in the ISM.

Accepted by Astronomy & Astrophysics

Preprints can be obtained by contacting tkendall@oal.ul.pt

Jobs

post-doctoral position
ASTROPHYSICIST
Royal Observatory of Belgium

In the framework of a collaboration between the ROB and several Belgian universities, applications are invited for a post-doctoral research fellowship to work in the area of AGB and post-AGB evolution at the Royal Observatory of Belgium (ROB).

The ROB has extensive expertise in these fields as well as in related ones and has been quite succesful in obtaining observing time at various large observatories including the VLT. The post is available for two years with the possibility of an extension of one or two years. The position could be started as soon as possible after the selection procedure has ended, and preferably not later than October 1, 2002.

The successful candidate will work as part of a large and expanding programme concerned with understanding the evolution of stars in the AGB and post-AGB phases, and the formation of planetary nebulae, including the possible role of binarity. She/He is expected to participate in and further develop the theoretical modelling aspects of the programme. We are particularly interested in a candidate to do NLTE modelling of expanding atmospheres of post-AGB stars. Candidates should have recently obtained a PhD in astrophysics and preferably should have a strong research record in modelling of stellar atmospheres, good communication skills, and ability to interact constructively with the other research staff.

A competitive salary is offered at the level of "Assistant" (about 40-45 kEuros gross salary, depending on experience) and is supported by health care and pension. The ROB is a national research institution located in Brussels, the capital of Belgium and of Europe. Belgium has access to all ESO telescopes, incl. VLT(I). The position includes access to very good computing facilities and some funding for research travel.

Applications should consist of a Curriculum Vitae, a list of publications, three letters of recommendation,and a description of research experience and interests. The selection procedure will start May 1, 2002, until the

position is filled.

For further information and submission of your application:
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