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Abstract of recently accepted papers

The dynamical evolution of the circumstellar gas around low-and intermediate-mass stars. II. The Planetary Nebula formation.

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We have studied the effect of the mass of the central star (CS) on the gas evolution during the planetary nebula (PN) phase. We have performed numerical simulations of PN formation using CS tracks for six stellar core masses corresponding to initial masses from 1 to 5 $M_\odot$. The gas structure resulting from the previous asymptotic giant branch (AGB) evolution is used as the starting configuration. The formation of multiple shells is discussed in the light of our models, and the density, velocity and H_α emission brightness profiles are shown for each stellar mass considered. We have computed the evolution of the different shells in terms of radius, expansion velocity, and H_α peak emissivity. We find that the evolution of the main shell is controlled by the ionization front rather than by the thermal pressure provided by the hot bubble during the early PN stages. This effect explains why the kinematical ages overestimate the age in young CSs. At later stages in the evolution and for low mass progenitors the kinematical ages severely underestimate the CS age. Large (up to 2.3 pc), low surface brightness shells (less than 2000 times the brightness of the main shell) are formed in all of our models (with the exception of the 5 $M_\odot$ model). These PN halos contain most of the ionized mass in PNe, which we find is greatly underestimated by the observations because of the low surface brightness of the halos.

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Preprints can be obtained by contacting villaver@stsci.edu
Also available from the URL http://arXiv.org/abs/astro-ph/0208323

The Henize sample of S stars. IV. New symbiotic stars

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The properties of the few symbiotic stars detected among the 66 binary S stars from the Henize sample are discussed. Two stars (Hen 18 and Hen 121) exhibit both a strong blue-violet continuum and strong H_α emission (FWHM of 70 km s^{-1}), whereas Hen 134 and 137 exhibit weak H_α emission. The H_α profiles are typical of non-dusty symbiotic stars belonging to class S-3 as defined by Van Winckel et al. (1993, A&AS 102, 401). In that class as in the Henize symbiotic S stars, He I, [N II] or [S II] emission lines are absent, suggesting that

the nebular density is high but the excitation rather low. The radial velocity of the centre of the H_α emission is identical to that of the companion star (at least for Hen 121 where this can be checked from the available orbital elements), thus suggesting that the H_α emission originates from gas moving with the companion star. For Hen 121, this is further confirmed by the disappearance of the ultraviolet Balmer continuum when the companion is eclipsed by the S star. Hen 121 is thus the second eclipsing binary star discovered among extrinsic S stars (the first one is HD 35155). A comparison of the available data on orbital periods and H_α emission leads to the conclusion that H_α emission in S stars seems to be restricted to binary systems with periods in the range 600 – 1000 d, in agreement with the situation prevailing for red symbiotic stars (excluding symbiotic novae). Symbiotic S stars are found among the most evolved extrinsic S stars.

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Preprints can be obtained by contacting svaneck@astro.ulb.ac.be
or via WWW on http://www-astro.ulb.ac.be/Html/ps.html#PRS

Time Variation in the Radio Continuum Emission Associated with the Surroundings of the Nucleus of the Planetary Nebula KjPn 8

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We present new, high sensitivity Very Large Array (VLA) continuum observations of the core of KjPn 8 made with arc second angular resolution. These observations were compared with similar observations taken 5.5 years before to search for variations that seemed to be present in previous observations. Our comparison indicates that the emission associated with the surroundings of the stellar nucleus decreased by 40% over this period. We tentatively attribute this decrease to variations in the ejection of gas from the central star.

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Sulfur, Chlorine, and Argon Abundances in Planetary Nebulae. III: Observations and Results for a Final Sample

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This paper is the fourth in a series whose purpose is to study the interstellar abundances of sulfur, chlorine, and argon in the Galaxy using a sample of 86 planetary nebulae. Here we present new high-quality spectrophotometric observations of 20 Galactic planetary nebulae with spectral coverage from 3700-9600 Å. A major feature of our observations throughout the entire study has been the inclusion of the near-infrared lines of [S III] $\lambda\lambda$9069,9532, which allows us to calculate accurate S^{+2} abundances and to either improve upon or convincingly confirm results of earlier sulfur abundance studies. For each of the 20 objects here we calculate ratios of S/O, Cl/O, and Ar/O and find average values of S/O=1.1E-2±1.1E-2, Cl/O=4.2E-4±5.3E-4, and Ar/O=5.7E-3±4.3E-3. For six objects we are able to compare abundances of S^{+3} calculated directly from available [S IV] 10.5μ measurements with those inferred indirectly from the values of the ionization correction factors for sulfur. In the final paper of the series, we will compile results from all 86 objects, search for and evaluate trends, and use chemical evolution models to interpret our results.

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Cerium: the lithium substitute in post-AGB stars

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In this letter we present an alternative identification for the line detected in the spectra of s-process enriched low-mass post-AGB stars around 6708 Å and which was interpreted in the literature as due to Li. Newly released line lists of lanthanide species reveal, however, the likely identification of the line to be due to a Ce II transition. We argue that this identification is consistent with the Ce abundance of all the objects discussed in the literature and conclude that in none of the low-mass s-process enriched post-AGB stars there is indication for Li-production.

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Preprints can be obtained by contacting maarten@ster.kuleuven.ac.be
or via WWW on http://arXiv.org/abs/astro-ph/0210343

Observations of [S IV] 10.5 μm and [Ne II] 12.8 μm in Two Halo Planetary Nebulae: Implications for Chemical Self-Enrichment

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We have detected the [S IV] 10.5 μm and [Ne II] 12.8 μm fine-structure lines in the halo population planetary nebula (PN) DdDm 1, and set upper limits on their intensities in the halo PN H 4-1. We also present new measurements of optical lines from various ions of S, Ne, O, and H for DdDm 1, based on a high-dispersion spectrum covering the spectral range 3800 Å – 1 μm. These nebulae have similar O/H abundances, (O/H) $\sim 1 \times 10^{-4}$, but S/H and Ne/H are about half an order of magnitude lower in H 4-1 than in DdDm 1; thus H 4-1 appears to belong to a more metal-poor population. This supports previous suggestions that PNe arising from metal-poor progenitor stars can have elevated oxygen abundances due to internal nucleosynthesis and convective dredge-up. It is generally accepted that high abundances of carbon in many PNe result from self-enrichment. To the extent that oxygen can also be affected, the use of nebular O/H values to infer the overall metallicity of a parent stellar population (for example, in external galaxies) may be suspect, particularly for low metallicities.

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Preprints can be obtained by contacting harriet@astro.as.utexas.edu
or via the WWW at http://lanl.arXiv.org/abs/astro-ph/0210356c.za¿

Pulsation at the tip of the first giant branch?

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The first results of our ongoing near-infrared (NIR) survey of the variable red giants in the Large Magellanic Cloud, using the Infrared Survey Facility (IRSF) and the SIRIUS infrared camera, are presented. Many very red stars were detected and found that most of them are variables. In the observed colour-magnitude diagram $(J-K, K)$ and the stellar K magnitude distribution, the tip of the first giant branch (TRGB), where helium burning in the core starts, is clearly seen. Apart from the genuine AGB variables, we found many variable stars at luminosities around the TRGB. From this result, we infer that a substantial fraction of them are RGB variables.

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Parameterizing the third dredge-up in asymptotic giant branch stars

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We present new evolutionary sequences for low and intermediate mass stars ($1M_{\odot}$ to $6M_{\odot}$) for three different metallicities, $Z = 0.02$, 0.008 and 0.004. We evolve the models from the pre-main sequence to the thermally-pulsing asymptotic giant branch phase. We have two sequences of models for each mass, one which includes mass loss and one without mass loss. Typically 20 or more pulses have been followed for each model, allowing us to calculate the third dredge-up parameter for each case. Using the results from this large and homogeneous set of models, we present an approximate fit for the core mass at the first thermal pulse, $M_{\rm c}^{1}$, as well as for the third dredge-up efficiency parameter, λ, and the core mass at the first dredge-up episode, $M_{\rm c}^{\rm min}$, as a function of metallicity and total mass. We also examine the effect of a reduced envelope mass on the value of λ.

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Radiative pumping of 1612 MHz OH masers: OH/IR sources with IRAS LRS spectra and 34.6 micrometer absorption feature.

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The population inversion which leads to the 1612 MHz OH maser emission has long been thought to be radiatively pumped. Since OH rotational lines involved in this pumping scheme lie in the far–infrared they became observable only after the launch of the ISO satellite. With the aim to investigate the pumping conditions of the 1612 MHz OH maser emission in more details we have searched the ISO Archive for SWS observations around 34.6 μm of 1024 OH/IR sources with IRAS LRS spectra from compilation of Chen et al. (2001). Surprisingly, among 81 OH/IR sources which have appropriate SWS data only already reported objects: VY CMa, IRC+10420 and the Galactic center, show clear 34.6 μm absorption line. We discuss possible reasons for non–detection of this pumping line.

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Preprints can be obtained by contacting szczerba@ncac.torun.pl
or via WWW on http://www.ncac.torun.pl/

Dissertation Abstract

The Influence of Poloidal Magnetic Fields on Astrophysical Outflows

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We have studied the effects of poloidal magnetic fields on two classes of outflows via time-dependent, numerical magnetohydrodynamic simulations. Correspondingly, this thesis is divided into two parts: a study of winds from isolated stars with dipole magnetic fields; and a study on outflows from pre-main sequence stars, surrounded by and interacting with accretion disks.

We begin with a study of the effects of stellar dipole magnetic field on winds from isolated stars. Our simulations indicate that a wind from the surface of a non-rotating AGB star, if sufficiently ionized, may be channeled into an outflowing disk by a dipolar field of only a few Gauss. This type of wind may be partly responsible for shaping planetary nebulae. If the star rotates, the additional magnetic pressure, associated with the azimuthal component of the field (generated by rotation), has the effect of enhancing the outflowing disk and simultaneously produces a jet. We show that the resulting quadrupolar density pattern (disk plus jet) in the wind may explain observations of reflected starlight in proto-planetary nebulae.

Next, we carry out a parameter study of an episodic magnetospheric inflation (EMI) model for launching outflows from young stellar objects (YSO's), first proposed by Hayashi et al. (1996) and Goodson et al. (1997). The basic mechanism produces an intermittent, collimated jet and an uncollimated, wide-angle wind and partially explains the mass loss and intermittent accretion of YSO's. We find that the EMI mechanism is robust, and the system is self-regulating (i.e., the outflow properties depend relatively weakly on the parameters we varied). Also, the addition of a weak vertical field initially threading the accretion disk has no effect on the EMI mechanism. However, we demonstrate that the weak vertical field can collimate the entire flow (including the component that is initially launched with a wide opening angle) into a physically broader and more powerful jet than produced by the central launching mechanism alone.

Infrared light on the composition of the dust surrounding carbon-rich stars

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We study the dust in the circumstellar environments of evolved C-rich stars in order to derive the composition of the dust and the mass loss history of evolved stars. We examine the dust using infrared (IR) data obtained with ESA's Infrared Space Observatory (ISO). The main advantage of observing in the mid-IR is that we are able to directly determine the dust composition from the vibrational fingerprints of the dust species since these fingerprints are all located in the mid-IR wavelength range.

In my thesis I describe the discovery of some new solid-state components in these environments, one of those is the first ever evidence for iron sulfide grains outside our solar system. We find such grains in the outflows of old stars and in the disks of young stars alike. The latter is an especially tantalising result because, on Earth, iron sulfide grains played an important role in the emergence of life and planets are believed form in those disks around young stars.

We also discovered the mysterious "21" μm feature in two planetary nebulae. The material that gives rise to this feature has evaded identification since the 1980's. We have suggested a link between the "21" μm feature and TiC nanocrystals. However, before the "21" μm feature had only been found around rather cool stars and this was interpreted as evidence that the carrier of the feature was rapidly destroyed. This is incompatible with the TiC identification because TiC is one of the most stable compounds known. Our discovery shows that the material that gives rise to the feature is more stable than previously believed.

We present a careful test of the magnesium sulfide identification for the "30" μm feature. We find that the differences in shape of this feature between the various sources can be explained by differences in temperature of the magnesium sulfide grains and the grain shape distribution. From radiative transfer modelling for the post-AGB stars HD 56126 we derive that the strength of the "30" μm feature is consistent with the amount of available Mg and S atoms.

We find several warm carbon-stars with cool magnesium sulfide. We suggest that this magnesium sulfide was formed during an earlier period of high mass loss and is now present in a detached shell around the star. Several of these objects are known to exhibit a detached dusty shell.

We study the emission of polycyclic aromatic hydrocarbon molecules (PAHs) in the surrounding of H II regions, Herbig AeBe and carbon-rich planetary nebulae. From a detailed comparison with newly available laboratory measurements of PAHs we find that the PAHs around C-rich planetary nebulae contain 100$-$200 C-atoms and have long straight edges while the PAHs in the surroundings of low- and high-mass young stellar objects have more ragged edges.

We constructed a detailed radiative transfer model for the post-AGB star HD 56126 in which we take, for the first time, the detailed composition of the circumstellar envelope into account. We find that this star has undergone a short ($<$1500 yr), strong ($>10^{-4}$ $M_{\odot}$/yr) mass loss burst, during which the entire envelope was lost. We explore the amount of TiC required to explain the strength of "21" μm feature. We find that the strength of the observed "21" μm feature can only be explained with nano-crystalline TiC if nano-crystalline TiC absorbs the stellar light $\sim$20 times more efficiently than bulk TiC. We also find that the 6$-$9 and 11$-$17 μm plateau emission features cannot be explained by hydrogenated amorphous carbon (HAC) grains in radiative equilibrium. HAC does not reach a high enough temperature to emit efficiently at 6 μm.

The main result from the research presented in this thesis is a much more complete understanding of the dust that condenses around carbon-rich evolved stars. For several sources the improved knowledge of the dust composition and the location of the dust allows us to also better constrain the mass-loss history and thus the evolution of the star.