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Abstract of recently accepted papers

Abundances of Planetary Nebula Hu1-2

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The ISO and IUE spectra of the elliptical nebula NGC 5315 is presented. These spectra are combined with the spectra in the visual wavelength region to obtain a complete, extinction corrected, spectrum. The chemical composition of the nebulae is then calculated and compared to previous determinations. The HST NICMOS observations of the nebula in 3 emission lines are also presented. These observations are used to determine the helium abundance as a function of position in the nebula. A discussion is given of possible evolutionary effects.

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Preprints can be obtained by contacting pottasch@astro.rug.nl
or via WWW on http://www.astro.rug.nl/Preprints/preprints.html

M Giants in MACHO, DENIS and ISOGAL

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A 'complete' sample of 174 M giants classified by Blanco (1986) and later than subtype M0 in the NGC 6522 Baade's Window clear field has been investigated to establish some general properties of cool Bulge stars. Photometric information has been obtained from the MACHO database to search for variablility and, where possible, to determine periods. Near- and mid-IR magnitudes have been extracted from DENIS and ISOGAL. Forty-six semi-regular (SR) variables and two irregular variables were found amongst the 174. Many M5 and all stars M6 or later show variation, whereas earlier subtypes (M1–M4) do not. The DENIS $I-J$ and $J-K_S$ colours and the luminosities of the M stars increase with M sub-class. K tends to increase with $\log P$ among the M-type SR variables. Almost all the variables were detected at 7μm during the ISOGAL programme. Excess radiation at 15μm, indicative of heavy mass-loss, is associated with high luminosity and late spectral type. The limit of sensitivity of the ISOGAL survey was such that the non-variables were not detected. Four probable M stars not listed by Blanco (1986), two of which are semi-regular variables, were detected by ISOGAL. In the

case of doubly-periodic SR variables, the longer periods have K-mags which place them close to the 'D' line of Wood (2000) in a K, log P diagram. The unusual MACHO light curve of one particular star, Blanco 26, shows the commencement of a long-period variation with an anomalously short and sharp event and appears to rule out a pulsational model for this phenomenon.

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The Master Catalogue of stars towards the Magellanic Clouds*

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The Master Catalogue of stars towards the Magellanic Clouds (MC2)** is a multi–wavelength reference catalogue. The current paper presents the first results of the MC2 project. We started with a massive cross–identification of the two recently released near–infrared surveys: the DENIS Catalogue towards the Magellanic Clouds (DCMC) with more than 1.3 million sources identified in at least two of the three DENIS filters (I J $K_{\rm S}$) and the 2nd Incremental Release of the 2MASS point source catalogue (J H $K_{\rm S}$) covering the same region of the sky. Both point source catalogues provide an unprecedented wealth of data on the stellar populations of the Magellanic Clouds (MCs). The cross–matching procedure has been extended to optical wavelength ranges, including the UCAC1 (USNO) and GSC2.2 catalogues. New cross–matching procedures for very large catalogues have been developed and important results on the astrometric and photometric accuracy of the cross–identified catalogues were derived. The cross–matching of large surveys is an essential tool to improve our understanding of their specific contents. This study has been partly supported by the ASTROVIRTEL*** project that aims at improving access to astronomical archives as virtual telescopes.
**http://vizier.u-strasbg.fr/MC2/
***http://www.stecf.org/astrovirtel/

Accepted by Astronomy & Astrophysics
Preprints can be obtained by contacting delmotte@astro.u-strasbg.fr
or via WWW on http://vizier.u-strasbg.fr/MC2/

Near-Infrared Observations of the IRAS/SiO Sources in the Galactic Bulge: a Large Scale Distribution

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Near-infrared photometric observations in the J, H, and K bands were made for 120 IRAS sources toward the Galactic bulge ($-10^\circ < l < 15^\circ$ and $|b| < 3^\circ$, excluding $|l| < 3^\circ$). They are well-confirmed, mass-losing late-type stars having accurate radial velocities derived from SiO maser observations. For 118 sources, single, unambiguous near-infrared counterparts were found within the errors of the IRAS/MSX positions, and for the other 2 sources, faint candidates only detectable in the K-band were found. From the J, H, K-band and IRAS 12 and 25 μm intensities, we estimated the spectral energy distributions of the sources, and obtained distances assuming a constant intrinsic luminosity. Adding all of the distance data of the IRAS/SiO sources in $-10^\circ < l < 25^\circ$ published in previous papers, we mapped the positions of 272 sampled stars onto the Galactic plane. The map clearly shows a bar structure, where the major axis of the bar is oriented $22^\circ(\pm 8^\circ)$ from the Sun–Galactic center line. We also reanalyzed the radial-velocity shift with distance in this sample. These analyses suggest that the data are consistent with the current bar theory of the Galactic bulge.

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The detection of iron sulfides in Planetary Nebulae

S. Hony[1]

Abundances of Planetary Nebula Hu1-2

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The ISO and IUE spectra of the elliptical nebula NGC 5315 is presented. These spectra are combined with the spectra in the visual wavelength region to obtain a complete, extinction corrected, spectrum. The chemical composition of the nebulae is then calculated and compared to previous determinations. The HST NICMOS observations of the nebula in 3 emission lines are also presented. These observations are used to determine the helium abundance as a function of position in the nebula. A discussion is given of possible evolutionary effects.

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We present and discuss the detection, through mid IR spectroscopy, of iron sulfides in the carbon rich ejecta of evolved stars. We find the spectroscopic signature of iron sulfides at 23 μm. We also find weak features at $\sim$34, 38 and 44 μm. The positions of these features correspond well with the resonances of the iron sulfide troilite. However, the relative strength of the 23 μm versus the other bands does not match the laboratory measurements, which suggests the presence of other iron sulfides besides troilite. The same broad feature around 23 μm has been found in young stellar objects. This detection may imply a carbon star origin for part of the iron sulfides found in meteorites and interplanetary dust particles.

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Preprints can be obtained by contacting hony@astro.uva.nl
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Stellar wind bubbles around WR and [WR] stars

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We study the dynamics of stellar wind bubbles around hydrogen-deficient stars using numerical simulations with time- and ion dependent cooling. We consider two types of hydrogen-deficient stars, massive WR stars, producing Ring Nebulae, and low mass [WR] stars, producing Planetary Nebulae. We show that for the Planetary Nebulae, the different cooling properties of the hydrogen-deficient wind lead to a later transition from momentum- to energy-driven flow, which could explain the observed turbulence of these nebulae. We find that Ring Nebulae should all be energy-driven, and show how comparing the bubble's momentum and kinetic energy to the input wind momentum and kinetic energy, can give misleading information about the dynamics of the bubble.

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Preprints can be obtained by contacting mellema@strw.leidenuniv.nl
or via WWW on http://www.strw.leidenuniv.nl/TheoryGroup/theo-publications.html
or via anonymous ftp on ftp://ftp.strw.leidenuniv.nl/pub/mellema/preprints/WR-Bubbles.ps.gz

Imaging the circumstellar envelope of OH 26.5+0.6

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Using the Berkeley-Illinois-Maryland-Association (BIMA) Millimeter Array, we were able to map the extreme OH/IR star, OH 26.5+0.6, in the ^{12}CO J=1-0 line transition. The CO emission is partially resolved with a deconvolved source size of $8.5'' \times 5.5''$ The spectrum shows that the blue-shifted emission is missing, most likely due to interstellar absorption. By modelling the infrared spectral energy distribution, we derive a dust mass loss rate of $1.9\times^{-6}$ $M_\odot$ yr^{-1}. ¿From this we are able to place an upper limit on the extent of the dusty envelope of 10^{16} cm while our BIMA map shows that the CO photodissociation radius extends out to about $7\,10^{16}$ cm. To best fit the BIMA observations and the higher CO rotational transitions using our full radiative transfer code, we needed to include a second, more tenuous AGB wind, outside the high density superwind to account for the observed flux. ¿From our model, we conclude that up to 80% of the CO flux comes from the unresolved superwind.

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Preprints can be obtained contacting kay@astro.su.se
or via anonnymous ftp on ftp.astro.su.se/pub/kay/OH26.ps.gz

High-velocity regions in planetary nebulae

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The internal velocity fields of planetary nebulae are studied with a resolution of 5 km s^{-1}. We analyze deep echelle spectra from three nebulae in the Bulge, the Sagittarius Dwarf and the SMC. No effects of metallicity

is seen, except possibly a slower onset of the fast wind from the central star. Robust evidence is found for the existence of a high-velocity shock at the inner edges of the nebulae. Such a shock is predicted in hydrodynamical models but had not previously been observed. The shock gas is accelerated by the fast wind from the central star. A similar shock at the outer edges traces the expansion of the ionized shell into the ambient AGB wind. Evidence for localized regions of high velocity is also found from lines of intermediate excitation, for two of nebulae. We explore several possible interpretations: (1) an embedded shock at intermediate radii, as predicted by hydrodynamic models at the position of the outer edge of the swept-up inner shell; (2) deviations form spherical symmetry, where in some directions the intermediate-excitation lines extend into the region of the outer shock; (3) An intermediate swept-up shell, as seen in some Galactic planetary nebulae. The remaining nebula, with a [WC] star, shows strong turbulence. This may trace a superposition of many embedded shocklets. We suggest a relation to the time-variable [WC] wind, giving a planetary nebula subjected to a multitude of sound waves.

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Preprints can be obtained by contacting gesicki@astri.uni.torun.pl
or via WWW on `http://www.astri.uni.torun.pl/~gesicki/GesZij2002.ps.gz`
or `http://www.astri.uni.torun.pl/~gesicki/GesZij2002.pdf`

Circular polarization of water masers in the circumstellar envelopes of late type stars

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We present circular polarization measurements of circumstellar H_2O masers. The circular polarization detected in the (6_{16}-5_{23}) rotational transition of the H_2O maser can be attributed to Zeeman splitting in the intermediate temperature and density regime. The magnetic fields are derived using a general, LTE Zeeman analysis as well as a full radiative transfer method (non-LTE), which includes a treatment of all hyperfine components simultaneously as well as the effects of saturation and unequal populations of the magnetic substates. The differences and relevances of these interpretations are discussed extensively. The field strengths are compared with previous detections of the magnetic field on the SiO and OH masers. We show that the magnetic pressure dominates the thermal pressure by a factor of 20 or more.

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Preprints can be obtained by contacting vlemming@strw.leidenuniv.nl
or via WWW on http://lanl.arXiv.org/abs/astro-ph/0208197

Astrometry of the stellar image of U Her amplified by the circumstellar 22 GHz water masers

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The 22 GHz H_2O masers in the circumstellar envelope of the Mira variable star U Her have been observed with MERLIN using a phase referencing technique to determine accurate astrometric positions. The positions

were compared with the optical positions obtained with the Hipparcos satellite to an accuracy of 18 mas. The absolute radio position of the brightest H_2O maser spot is found to match the optical position, indicating that this spot is the stellar image amplified by the maser screen in front of it. The occurrence of an amplified image in the 22 GHz maser can be used to accurately determine the positions of the H_2O with respect to the star as well as with respect to the SiO and OH masers. Our observations seem to indicate that the star is not in the centre of the distribution of maser spots, which has been interpreted as a ring.

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Dust grain properties in atmospheres of AGB stars

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We present self-consistent dynamical models for dust driven winds of carbon-rich AGB stars. The models are based on the coupled system of frequency-dependent radiation hydrodynamics and time-dependent dust formation. We investigate in detail how the wind properties of the models are influenced by the micro-physical properties of the dust grains that enter as parameters. The models are now at a level where it is necessary to be quantitatively consistent when choosing the dust properties that enters as input into the models. At our current level of sophistication the choice of dust parameters is significant for the derived outflow velocity, the degree of condensation and the estimated mass loss rates of the models. In the transition between models with and without mass-loss the choice of micro-physical parameters turns out to be very significant for whether a particular set of stellar parameters will give rise to a dust-driven mass loss or not.

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Preprints can be obtained at http://arXiv.org/abs/astro-ph/0209247 or by contacting anja@astro.ku.dk

Confirmation of SBS 1150+599A as an Extremely Metal-Poor Planetary Nebula

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SBS 1150+599A is a blue stellar object at high galactic latitude discovered in the Second Byurakan Survey. New high-resolution images of SBS 1150+599A are presented, demonstrating that it is very likely to be an old planetary nebula in the galactic halo, as suggested by Tovmassian et al (2001). An Hα image taken with the

WIYN 3.5-m telescope and its "tip/tilt" module reveals the diameter of the nebula to be 9.2″, comparable to that estimated from spectra by Tovmassian et. al Lower limits to the central star temperature were derived using the Zanstra hydrogen and helium methods to determine that the star's effective temperature must be >68,000K and that the nebula is optically thin. New spectra from the MMT and FLWO telescopes are presented, revealing the presence of strong [Ne V] λ3425, indicating that the central star temperature must be >100,000K. With the revised diameter, new central star temperature, and an improved central star luminosity, we can constrain photoionization models for the nebula significantly better than before. Because the emission-line data set is sparse, the models are still not conclusive. Nevertheless, we confirm that this nebula is an extremely metal-poor planetary nebula, having a value for O/H that is less than 1/100 solar, and possibly as low as 1/500 solar.

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or via WWW on http://burro.astr.cwru.edu/johnf/sbs1150.ps

Discovery of Enhanced Germanium Abundances in Planetary Nebulae with the *Far Ultraviolet Spectroscopic Explorer*

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We report the discovery of Ge III λ1088.46 in the planetary nebulae (PNe) SwSt 1, BD+30°3639, NGC 3132, and IC 4593, observed with the *Far Ultraviolet Spectroscopic Explorer*. This is the first astronomical detection of this line and the first measurement of Ge ($Z = 32$) in PNe. We estimate Ge abundances using S and Fe as reference elements, for a range of assumptions about gas-phase depletions. The results indicate that Ge, which is synthesized in the initial steps of the *s*-process and therefore can be self-enriched in PNe, is enhanced by factors of ≥ 3 - 10. The strongest evidence for enrichment is seen for PNe with Wolf-Rayet central stars, which are likely to contain heavily processed material.

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Preprints can be obtained by contacting sterling@astro.as.utexas.edu
or via the WWW at http://lanl.arXiv.org/abs/astro-ph/0208516

The α-element abundances in the most oxygen-poor planetary nebula PN G 135.9+55.9

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We present extensive new spectroscopy and imaging of PN G 135.9+55.9. We use these data as constraints to photoionization models to derive limits on the oxygen abundance. We find that PN G 135.9+55.9 has an oxygen abundance less than 1/50 of the solar value. Our models favour a value of $12 + \log \mathrm{O/H}$ between 5.8 and 6.5 dex, confirming that PN G 135.9+55.9 is the most oxygen-poor planetary nebula known (Tovmassian

et al. [**?**]). We also derive Ne/O = 0.5 ± 0.3, S/O < 0.094, and Ar/O < 0.23. Although the value of Ne/O is nominally high, it need not imply that the progenitor of PN G 135.9+55.9 converted any of its initial oxygen abundance to neon. The helium abundance appears to be very low, He/H ~ 0.08, but a precise determination will require a much more detailed study. We find that Hα/Hβ is lower than expected and perhaps variable, a finding for which we have no clear explanation.

This paper is based upon data obtained at the Canada-France-Hawaii Telescope, the Nordic Optical Telescope, the Observatorio Astronómico Nacional in San Pedro Mártir, and the William Herschel Telescope.

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H_2O in Stellar Atmospheres II. ISO spectra of cool red giants and hydrostatic models

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We present 26 ISO-SWS spectra taken from a sample of 13 M-type Semiregular, Lb and Mira variables and covering the wavelength range between 2.36 and 5 μm at a medium resolution. All of the studied objects show intense water bands producing a deep absorption dip around 2.5 μm. Features of CO, OH, SiO and CO_2 are also visible. Using the new H_2O linelist published in the first paper of this series and available opacity data for the other important molecules, we calculated a grid of hydrostatic MARCS atmospheres and the corresponding synthetic ISO-SWS spectra. Based on the comparison with these theoretical results the ISO observations can be divided into four classes. The first two groups include the spectra of the Semiregular (SRb) and Lb variables in our sample. For all of them the region between 2.36 and 4.2 μm can be quite well reproduced by our hydrostatic models. Only the predicted SiO bands above 4 μm are in some cases too strong which is due to known dynamical effects. Depending on the temperature (above or below 3000 K) of the atmosphere, which mainly determines the intensity of the water depression at 2.5 μm, the spectra of the Semiregular and Lb variables fall into the first or second class. The third group consists of observations of Mira stars obtained around maximum light where the range between 2.36 and 4.2 μm can be fitted with our MARCS models except for a strong emission bump appearing in the ISO-SWS data in the region of the SiO features and the slope very close to the short wavelength border. Finally, the last type of spectra corresponds to Mira variables during the phases around the minimum of their visual light curve. For this class the observed water absorption at 2.5 μm is much more intense than in any hydrostatic atmosphere with a realistic choice of effective temperature and surface gravity. Thus, we conclude that dynamical models are needed to explain the ISO-SWS data of Mira stars. For all of the cooler objects from our sample the predicted CO_2 bands between 4.2 and 4.6 μm are too weak which may be due to the opacity data.

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Dissertation Abstract

Molecular gas and dust around evolved stars

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Thesis work conducted at: Astronomical Institute "Anton Pannekoek", University of Amsterdam

Ph.D dissertation directed by: T. de Jong & L.B.F.M. Waters

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The work presented in this thesis starts with the discovery of CO_2 emission bands between 12 – 18 μm in the spectra of oxygen-rich AGB stars that also exhibit a dust feature at 13 μm. The excitation temperatures derived from the CO_2 bands are rather high, suggesting the bands are formed in the so-called *warm molecular layer* or *extended envelope*. The correlation between the strength of the CO_2 bands and the strength of the 13 μm feature indicates that also the carrier of the 13 μm feature is formed in this layer. A simple model for the circumstellar layer in which the CO_2 bands are formed – assuming LTE and an isothermal slab geometry – can be successfully applied to the high-resolution SWS spectrum of EP Aqr. It is found that each of the individual CO_2 bands in the 12 – 18 μm region can be used to probe a slightly different region in the extended atmosphere. The CO_2 bands in this wavelength range therefore offer a powerful tool to determine the temperature and density variations in the extended atmosphere.
We subsequently analyze the SWS spectra of a sample of 24 O-rich AGB stars. We present an inventory of the dust features between 8 and 27 μm in these spectra, revealing large variations in both the amount and the chemical composition of the dust. The spectra show a wealth of dust features, and in a few spectra, amorphous silicates – often the dominant dust component in spectra of O-rich AGB dust shells – are hardly present. We tentatively identify a dust feature at 19.5 μm with MgFeO, and corroborate an earlier tentative identification of a feature at 11 μm with compact amorphous Al_2O_3 grains. All spectra furthermore also exhibit the 13 μm feature which might possibly be due to spinel ($MgAl_2O_4$). These grains represent relatively simple dust species, and are probably amongst the first dust seeds formed in the extended atmosphere.
An inventory of the molecular bands present in the same spectra between 2.3 and 8 μm shows that molecular bands due to OH, CO, H_2O, SiO, CO_2 and SO_2 are commonly observed in these objects. Variations in the global observational characteristics of these molecular bands suggest a layered structure of the extended atmosphere, in which some molecular bands originate from close to the central star, whereas others originate in layers further out.
We furthermore devise a new method to determine excitation temperatures and column densities for the different molecular bands, using template spectra which are presented in an Appendix. We applied this method to our sample, and found that the derived temperatures and column densities confirm the layered structure of the extended atmosphere. OH, CO, H_2O and SiO bands are generally found to be formed closer to the stellar photosphere than CO_2 and SO_2. As opposed to Semi-Regulars, Mira variables are also found to be surrounded by a dense water layer which is optically thick over a considerable wavelength range in the IR. This water layer then provides the IR continuum against which molecules such as CO_2 and SO_2 can absorb.

The second part of this thesis deals with a single object, the binary post-AGB star HR 4049. We present the SWS spectrum of HR 4049 between 12 – 18 μm, clearly exhibiting CO_2 bands. This is surprising as HR 4049 is considered to be a carbon-rich object based on the presence of strong PAH bands and features due to nano-diamonds. Moreover, the CO_2 spectrum shows bands due to many different CO_2 isotopomers containing ^{13}C, ^{17}O and ^{18}O. Isotopic ratios derived for the different oxygen isotopes show that both the $^{16}O/^{17}O$ and $^{16}O/^{18}O$ ratios are at least one order of magnitude lower than ever measured before. We also present an analysis of the Spectral Energy Distribution (SED) and the star-subtracted IR dust emission between 1 μm and 850 μm for HR 4049. We show that the dust emission can be perfectly reproduced by a single temperature blackbody

at about 1150 K. Moreover, the energy emitted in the IR amounts to one-third of the total stellar luminosity. This can only be explained by the presence of a circumbinary disk which is vertically very extended and which must be gas-rich. To explain both the blackbody shape of the IR excess and the IR dust luminosity, we present results from radiative transfer calculations and argue that the blackbody radiation is likely due to a fat, very optically thick circumbinary disk.

Announcement

The third Asymmetric Planetary Nebula workshop is scheduled for 28 July - 1 August 2003 at Mount Rainier National Park near Seattle WA USA. A preliminary description of the workshop can be found at

http://www.astro.washington.edu/balick/APN/

The web page describes how to get on the mailing list for announcements. Registration opens in the fall.