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Abstracts of recently accepted papers

The optical spectrum of HR 4049 (includes a line identification from 3650 to 10850 Å)

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High-resolution optical spectra (UES/WHT) of the extreme metal-poor post-AGB star HR 4049 were obtained at four different orbital phases. The spectra cover the wavelength region from 3650 Å to 10850 Å at a resolution of $R = 5.2 \times 10^4$. These observations are supplemented with four high-resolution spectra of the NaI D1 & D2 and CaII K lines at $R \approx 10^5$ (CAT/CES). The optical spectrum shows 217 spectral lines: the Balmer series (Hα - H35), the Paschen series (P9 - P23), NI, OI and numerous CI lines. We show that the lines of Hα, Hβ, Hγ and NaI D show significant changes in profile between different observation dates. Nine components were identified in the profile of the NaI D lines of which three are circumstellar and six interstellar. The stronger CI lines are asymmetric and we derive a post-AGB mass-loss of $\dot{M}= 6 \pm 4 \times 10^{-7}$ $M_\odot$ yr^{-1} from the asymmetry. The [OI] 6300 Å line has been detected in emission at the system velocity and we argue that the emission is from an almost edge-on disk with a radius of about 20 R_*.

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K 4–55: a bipolar planetary nebula observed near pole-on

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A comprehensive study of the planetary nebula K 4–55 is presented. In addition to CCD narrow band images, spatially resolved low-dispersion and high-resolution spectra were obtained. This has allowed the different morphological features in the images to be connected with the kinematics and with the physical information, leading to the establishment of the complex nebular structure.

K 4–55 is a new multiple-shell planetary nebula displaying three different parts: a faint halo that extends up to 2 arcmin from the main nebula; an outer part revealed by the kinematical study as a pole-on bipolar structure; and an inner, bright ring. The bipolar structure is expanding at ∼100km s^{-1} at the poles, while the halo

has $V_{exp} \leq 8.6$km s^{-1}. The inner ring exhibits intriguing kinematics, indicating a likely presence of rotation. Abundance variations are found throughout the nebula, with a N/O abundance ratio enhancement in the [N II]-bright central ring, whereas the extended halo presents a much smaller ratio. The N/O ratio reported is among the highest ever found in Planetary Nebulae. The outer halo is consistent with the AGB wind, whereas the inner nebula was formed during a later mass loss phase.

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Molecules, Dust and the Structure of Circumstellar Envelopes

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Radio continuum and spectral line emission from the photospheres and circumstellar shells of evolved cool giant stars trace their size, shape and mass loss history. The stars themselves are larger at radio than at optical wavelengths; continuum emission is seen from circumstellar dust as well as from the photosphere; and asymmetries in the envelopes may be related to asymmetries in the stars themselves.

Discovery of Strong Vibrationally Excited Water Masers at 658 GHz toward Evolved Stars

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We report the astronomical discovery of the $1_{10} \rightarrow 1_{01}$ rotational transition within the $\nu_2 = 1$ vibrationally excited state of water vapor (H_2O). Using the 10.4 m telescope of the Caltech Submillimeter Observatory, we detect strong maser emission in this line, which has a frequency near 658 GHz, toward a diverse sample of oxygen-rich red giant and supergiant stars. In circumstellar envelopes these 658 GHz H_2O masers appear to be as common as SiO masers and H_2O masers in other transitions, while we fail to detect 658 GHz H_2O emission toward the W49 N and W51 N star-forming regions. For all of the 11 stars detected, the luminosity in the 658 GHz H_2O transition is comparable to or higher than the luminosity of any other known SiO or H_2O maser line.

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The Optical Spectrum of the Young Planetary Nebula Hubble 12

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The remarkable, young, compact planetary nebula, Hubble 12, renowned for its extended envelope which radiates the lines of molecular hydrogen, excited by fluorescence, has a dense core of complex structure. We present high dispersion measurements of the spectrum from 366 nm to 1005 nm: if the emission lines of [N II], [O III],

and [S III] originate in the same strata, the diagnostics suggest a zone with an electron density of ∼500,000 cm^{-3}, and $T_\epsilon \sim$ 13,600 K but lower densities and temperatures are indicated by the auroral/nebular line ratios of other emissions such as those of [O II], [S II] and the nebular line ratios of [Cl III], [Ar IV] and especially [N I]. The chemical composition of Hubble 12 is hard to establish, because of the great range in density and temperature of the emitting layers. We discuss arguments for and against the progenitor star as an oxygen or metal deficient object. A newly developed density contrast theoretical model is applied to this bipolar object, but a convincing theoretical model must await optical monochromatic images of high spatial resolution.

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The Spectrum of IC 351

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International Ultraviolet Explorer (*IUE*) & optical region spectroscopic observations are presented for the moderately high excitation planetary nebula, IC 351. Most of the atoms are distributed over a narrow range of ionization. Thus [N II] & [S II] are weak; [Ne IV] is prominent but [Ne V] is missing. It appears that the metal/hydrogen ratio is smaller than in the Sun. No Si lines are seen either in optical or UV regions. It is suggested that virtually all Si atoms are locked in grains. The ionization correction factor method fails utterly for N, for example. Hence *IUE* data are essential for chemical composition estimates. Until high spatial resolution images are available, construction of a new theoretical model does not seem warranted.

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Semiregular variables of types SRa and SRb. New JHKL′M-photometry for 44 stars.

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This paper supplements Kerschbaum & Hron (1994), where new JHKL′M observations of 200 Semiregular variables (SRVs) of types SRa and SRb were presented with additional 44 near infrared observations and 5 literature data sets. The total sample was defined in Kerschbaum & Hron (1992) by means of a certain limit in bolometric magnitude. From the sample of 350 objects, 303 now have near infrared (NIR) photometry. In total 339 datasets are available because of some multiple observations. A detailed analysis of the whole dataset will be presented in a forthcoming paper.

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Semiregular variables of types SRa and SRb. Energy distributions and stellar parameters.

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Semiregular variables of type SRa and SRb are studied by fitting combinations of blackbodies to new near infrared and IRAS data. The fitted parameters T^*, T^d and R^d/R^* are related to physically meaningful quantities.

For the O-rich cases all 'blue' objects can be reasonably well approximated by only one blackbody whereas the 'red' and the 'Mira' SRVs need two. The T^* values, reflecting mainly offsetted ($-500\,\mathrm{K}$), effective temperatures for objects with small to moderate mass loss, are significantly higher in the 'blue' SRV cases. A small difference between the T^* distributions of 'red' and 'Mira' SRVs seems to be present: with a few exceptions most of the 'Mira' T^* values are concentrated in the cold half of the 'red' SRV distribution. Carbon-rich objects differ significantly from the O-rich ones in their fit parameters. Sometimes 'unphysically' low T^* are found – a result of circumstellar reddening in the high mass loss cases. Also lower values of T^d, accompanied by normal T^*s and large shell radii are common. S-stars populate a similar region as the optically thin carbon stars.

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Shell Masers

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We present the analytical solution of a maser shaped like a spherical shell. We determine the general condition on the size of the central cavity at which a sphere becomes a shell maser, and derive the intensity, beaming angle and observed size of both unsaturated and saturated shells.

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Starspots the the Generation of Aspherical Stellar Winds

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In this paper I investigate the effect of starspots on the development of AGB wind asphericities. I begin with the assumption of large, cool starspots in an AGB photosphere and determine the contrast in wind density for gas parcels above the spot compared with those above the "normal" phosphere. My calculations use the results of Bowen's (1988) AGB outflow models where the wind is accelerated by radition pressure on dust. In Bowen's models the dust condenses from gas parcles driven to large distances above photosphere by stellar pulsation. My calculations, which assume radiative equilibruim between gas parcels and the local stellar radiation field, show that the wind above the spots will be launched closer to the star and, therefore, at higher densities than the wind above the normal photosphere. I examine two specific cases for the distribution of starspots: The development of toroidal winds from starspots in an equatorial band; The development of of clumpy flows from a single large spot. The results show that, given the assumptions inherent in the model, significant departures from an isotropic wind can be produced by cool starspots. The density enhancements produced by the spots are large enough to account for the development of elliptical and perhaps some bipolar planetary nebulae under the interacting stellar winds model.

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Local space density and formation rate of planetary nebulae

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Individual distances of 50 nearby planetary nebulae are determined using a variety of methods, but excluding statistical methods or distance scales. These distances, together with a discussion of the sample completeness,

are used to determine local PN formation rate. Together with the brightness of the nebula, its ionized mass is derived. The evolution of the ionized mass is discussed. As a by-product, the Zanstra temperature of the central stars of the optically thick nebulae is found. Interestingly this temperature indicates that the DA white dwarfs in the sample are considerably hotter than previously thought. Finally, with the help of the galactic bulge PN, a luminosity function for PN in the galaxy is derived.

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The shapping of planetary nebulae : asymmetry in the external wind

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We have modelled planetary nebulae (PNe) in the context of the interacting stellar winds model. If the two interacting winds have constant properties, the velocity of the PN shell tends towards a constant with time and the shape becomes self-similar. Additionally, if the velocity of the fast wind is much higher than the expansion velocity of the shell, the interior of the hot shocked bubble becomes isobaric. Using semi-analytical methods, complemented by hydrodynamic simulations, we have calculated the shapes of PNe in the self-similar stage. An asymmetric density profile is assumed for the slow outer wind. The asymmetry is modelled using different functions, which depend on the degree of asymmetry and the steepness of the density profile in the angular direction. We include the effects of the ambient wind velocity, which has not received much attention since the work of Kahn & West (1985). The fact that typical PNe velocities (10-40 $km\,s^{-1}$) are only marginally greater than typical red giant wind velocities (5-20 $km\,s^{-1}$) indicates that this is an important parameter. The morphological appearance is a consequence of the density contrast, steepness of the density profile and velocity of the ambient medium; classification of PNe purely on the basis of the first two factors may be misleading. Moderate values of the density contrast result in a cusp at the equator. A higher density contrast coupled with a low velocity for the external medium gives rise to extremely bipolar nebulae. For large density contrasts and a significant value of the slow wind velocity, the surface density maximum of the shell shifts away from the equator, giving rise to peanut-shaped structures with pronounced equatorial bulges. If the external wind velocity is small compared to the expansion velocity of the nebula, the PNe tend to be more bipolar, even with a moderate density contrast. If the PN velocity is close to that of the external wind, the shape is relatively spherical. However, a velocity asymmetry in the external wind can lead to a bipolar shape if the equatorial velocity is sufficiently low. Our numerical simulations show that asymmetric PN shells are corrugated because of Kelvin-Helmholtz instabilities. They also indicate that several doubling times are needed to approach the self-similar state. A ratio of interior sound speed to shell velocity $\gtrsim 10$ is found to yield nebulae whose shapes match those given by the isobaric approximation.

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Accurate Wavenumbers for Mid-Infrared Fine-Structure Lines

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We present accurate new wavenumbers for a set of 13 mid-infrared fine-structure lines. The wavenumbers were determined from observations of the planetary nebula NGC 7027 and of the red supergiant α Scorpii. Most of the new wavenumbers are good to within 0.0025%, or 8 km s^{-1}. We provide details on the measurements

and present an analysis of the errors. In addition, we present the first observations of hyperfine splitting in the [Na IV] 1106 cm^{-1} line, rough line intensities for NGC 7027, and a map of the [S III] emission in NGC 7027.

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Jobs

Post Doctoral Research Associate, University of Washington

Applications are invited for an observational or theoretical postdoctoral position at the University of Washington in Seattle in the research areas of nebular astrophysics, nebular gas dynamics (with special emphasis on the effects of stellar winds), stellar mass-loss processes in the nuclei of planetary nebulae and their progenitors, or closely related fields. The start date is flexible. The starting salary is $3,031 per month.

Postdocs at UW have access to the 3.5m telescope at Apache Point Observatory (equipped with a double mid-resolution spectrograph, an Echelle, and a 2-5-micron IR imager/grism system) and the 0.8m telescope at Manastash Ridge Observatory. The two-year position may be extended to three years if additional funding is secured.

Applicants must have a PhD in astronomy. Send a 2-page statement of relevant experience, a 1-page statement of professional goals for the position, a curriculum vitae and bibliography, copies of two recent publications, and a letter stating optimum range of start dates and the names and addresses (with phone and email) of three people who can provide knowledgeable professional recommendations, all in one mailing, before 15 October 1995.

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