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From the editors

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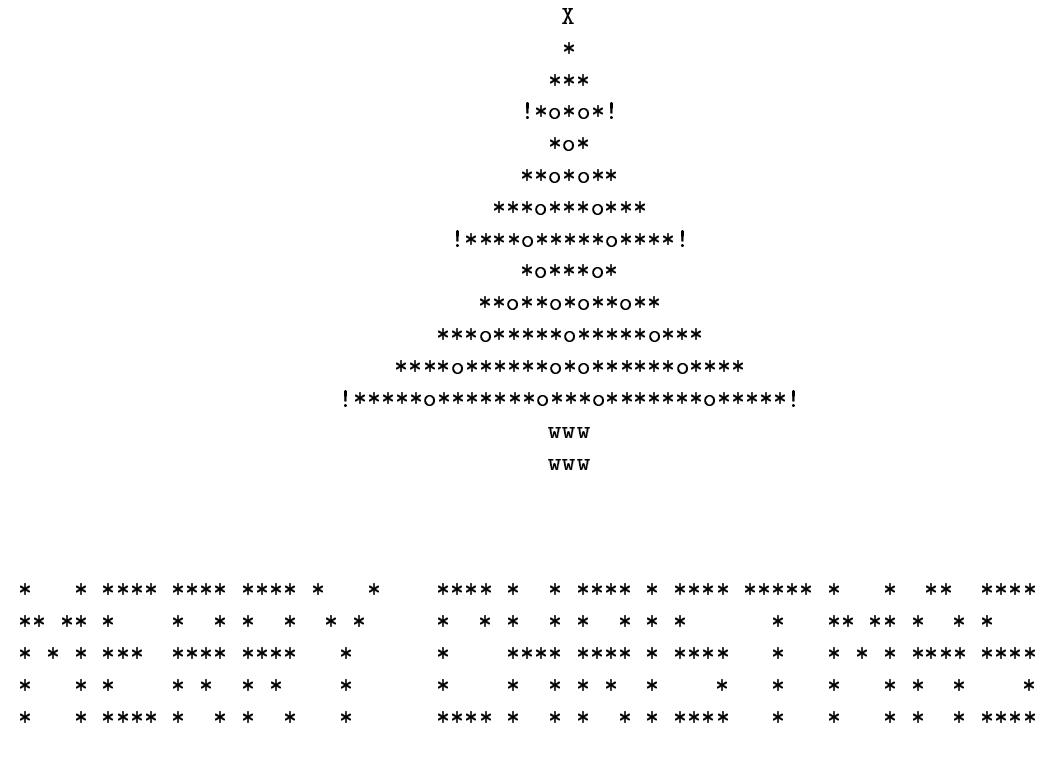
Thierry Forveille and Claudine Kahane



Abstracts of recently accepted papers

The rich O II recombination spectrum of NGC 7009: new observations and atomic data

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We present new spectrophotometric observations of the rich O II optical recombination line spectrum of NGC 7009, obtained at a spectral resolution of about 1 Å (FWHM). New intermediate coupling quantal calculations of O II radiative recombination coefficients for the 3d – 3p and 4f – 3d transitions are presented. The effect of departure from pure LS-coupling is shown to be important. Excellent agreement is found between the observed relative intensities of the O II lines and those calculated from recombination theory allowing for intermediate coupling effects. C, N and O abundances based on our recombination line measurements are derived. In all cases, they are about a factor of five higher than the corresponding values deduced from collisionally excited lines, indicating that the discrepancy between the abundances derived from these two different types of emission lines, previously known to exist for C^{2+}, is a common phenomenon and is probably caused by the same physical process. The nature of this process is still not known. If the discrepancy is due to temperature fluctuations, the implied *r.m.s.* temperature fluctuation parameter t^2 is about a factor of two larger than that derived by comparing the temperatures deduced from the [O III] forbidden line ratio and from the ratio of the nebular continuum Balmer discontinuity to Hβ. However, if we adopted the electron temperature derived from nebular continuum Balmer discontinuity instead of that from the [O III] forbidden line ratio, the C and N abundances deduced from ultraviolet collisionally excited lines would come into agreement with those deduced from the optical recombination lines, although the abundance of oxygen deduced from the optical forbidden lines would still be a factor of two lower than the corresponding value obtained from the optical recombination lines. The O/H abundance ratio derived from our recombination line analysis of NGC 7009 is more than a factor of two higher than the solar oxygen abundance.

Accepted by MNRAS *For preprints, contact* xwl@star.ucl.ac.uk

Neutral carbon far-red forbidden line emission from planetary nebulae

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The temperature-sensitive neutral carbon forbidden lines at 8727, 9824 and 9850 Å have been measured simultaneously for the first time from a planetary nebula. The nebulae NGC 2346, NGC 2440, NGC 3132 and IC 4406 were observed. Accurate rest wavelengths of these lines are obtained. The observed line ratios I(λ9824 + λ9850)/I(λ8727) are consistent with collisional excitation by electron impacts. It is demonstrated that radiative recombination and stellar continuum fluorescence are unimportant in exciting the observed [C I] lines, with the possible exception of NGC 2440 where contribution from the former process can not be ruled out. For NGC 2346, NGC 3132 and IC 4406, the observed [C I] line ratios yield electron temperatures between 7400 and 8000 K, about 1800 to 2800 K lower than those deduced from the [N II], [S III] and [O III] line ratios that we also measured. Electron densities have been derived from the observed [N I], [S II] and [Cl III] doublet ratios.

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The Spectrum of the Planetary Nebula, NGC 6886

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The relatively young, high excitation planetary nebula (PN) NGC 6886 shows a remarkable variety of lines from both high and low excitation stages, i.e., from N^0 to N^{4+}, and as a result it provides unique opportunities for detailed studies of physical processes using a theoretical model. By combining Hamilton Echelle observations with UV data secured with the *International Ultraviolet Explorer* (IUE), and with available IR data, we can obtain improved diagnostics and elemental abundances which should supply insights into nucleogenesis processes and properties of the progenitor star. Improved theoretical nebular models are employed. The chemical composition of this high excitation planetary nebula is found from ionic concentrations and also from a theoretical model. Except for Ne, Si, and Cl, the agreement between the abundances calculated using the two methods is generally remarkably good. The C/H ratio is enhanced by about 15 – 20 percent above the solar value; but the N/H & Ne/H, and probably Si/H ratios, are close to those of the sun. The other "metal"/H ratios and He/H seem to be lower than in the sun and O is depleted. If pronounced T_ϵ fluctuations are assumed we can raise the abundances of O, S, Cl, & Ar to approximately solar values, but then C, N, & Ne are substantially enhanced. Since the distance is poorly determined, it is difficult to establish evolutionary parameters.

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The Optical Spectrum of NGC 7009, I – A Low Excitation Bright Ring Region on the Major Axis

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Recent observations suggest NGC 7009 has a very complicated structure, see e.g. Balick et al. (1994). Detailed high spectral resolutions observation of the spectrum of NGC 7009 have been made for two regions in the bright ring on the major and minor axes, respectively, for the wavelength region 3650$\mathring{A}$ to 10050$\mathring{A}$, using the Hamilton echelle spectrograph of Lick Observatory. In this article we present only the results for the major axis. We have analyzed the nebular spectra with aid of theoretical photoionization models: 1) it appears that such a photoionization model can fit the emission reasonably well in the bright ring; 2) it is unlikely that the knots lie along an axis which is highly inclined with respect to the observer, an idea which was introduced from kinematical studies, wherein the knots are considered as a byproduct of highly collimated outflows.

NGC 7009 is Oxygen rich because the O/C ratio exceeds 1. The relative abundances of C, O, & K appear to be less abundant than in the sun; abundances of other 'metals' seem to be comparable with the solar values. With the help of the model, a comparison of the Hamilton data with the previous image-tube scanner (ITS) data suggests that a variation in nitrogen abundance may exist in NGC 7009, a result in harmony with that obtained by Balick et al (1994).

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The Optical Spectrum of NGC 7009, II – A High Excitation Bright Ring Region on the Minor Axis

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Observational data obtained for a small high excitation region of the North bright ring along the minor axis of NGC 7009 for the region 3650$\mathring{A}$ to 10050$\mathring{A}$, have been analysed. From various collisional lines, plasma diagnostics and chemical abundances are found for this region. Our analysis shows that emission from the bright ring (or rim) along the minor axis appears to be the combined contributions from two regions, a) a dominant optically thin, high temperature, low density (stratum) and b) a region of relatively relatively small size and low temperature & high density. The chemical composition resembles that found in the bright ring at the end of the major axis, but the intricate and largely unknown structure of this planetary nebula (PN) complicates the analysis considerably. Most of the differences arise from inherent uncertainties in the observational data, nebular structural irregularities, the model, and atomic parameters as reported in the preceding paper (Hyung & Aller 1994). Some elements at least N, may be more abundant in the knot at the edge of the major axis (Balick et al. 1994).

Analyses of the low & high excitation collisional line features at the bright ring is important in the interpretation of the nebular geometry: The bright ring (or rim) appearance in the low excitation line monochromatic images is more likely to be the projected effect of a high density (low excitation) equatorial ring, which is embedded in a low density (high excitation) shell. We compare results from permitted lines of OII, NII etc., interpreted as recombination features for regions in the ring at the end of the major and minor axes. High spatial resolution monochromatic imaging of NGC 7009 is urgently needed.

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Near-Infrared Polarimetric Imaging of the Bipolar Nebula OH 231.8+4.2: The Death of a β Pic-like System?

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The source OH 231.8+4.2 consists of a Mira variable star embedded in a highly collimated bipolar nebula, and thus appears to be representative of a transitional stage between red giant and planetary nebula. We obtained polarimetric near-infrared images of this source to ascertain its density structure. The patterns of polarization revealed in J and K images are characteristic of scattering of light from the central star by dust distributed in bipolar lobes. The signature of a dense circumstellar disk, previously hypothesized to explain the obscuration of the central star at optical and near-infrared wavelengths, is evident in the polarization maps and in a map of J−K color. Combined with the polarization information, the measured color gradients across the bipolar lobes suggest that the lobes are evacuated bubbles. We use the images to derive absorbing and scattering column densities of dust grains as functions of position within the nebula. The results for the total absorbing and scattering dust masses are similar, at $\sim 10^{-2} M_{\odot}$. This similarity lends further weight to a model in which the bulk of the dust mass of the nebula lies along the lobe walls.

Various lines of evidence suggest that only a small fraction of the total nebula mass resides in the circumstellar disk. This finding would appear to set OH 231.8+4.2 apart from other "classical" evolved bipolar nebulae, in which disks may dominate the circumstellar masses. We consider the possibility that the disk in OH 231.8+4.2 originated as a result of the influence of a binary companion to the Mira variable. Alternatively, we propose that the OH 231.8+4.2 nebula may be the endpoint of stellar evolution for an early A star that was surrounded throughout its main sequence lifetime by a particulate disk. Such a disk might have resembled the dusty disk around β Pic and, like that structure, would have had to be continually replenished in order to survive until the

central star's ascent of the red giant branch. This model naturally explains the confinement of bipolar planetary nebulae to low galactic latitudes.

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The Physical and Chemical Properties of Circumstellar Envelopes

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An overview is given of recent results on some basic properties of the circumstellar envelopes of evolved stars. The focus is on well studied examples (e.g., IRC+10216, α Orionis, NGC7027) which illustrate envelopes of different types and at different stages of evolution. The close connection between the physical and chemical properties of the envelopes is emphasized.

Review presented at the Edinburgh meeting, "Circumstellar Matter", August, 1994 *For preprints, contact* huggins@acfcluster.nyu.edu

Evolution from the AGB through the Planetary Nebulae Stage

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The evolution of advanced stellar configurations is intimately connected to mass losses from the surface by stellar winds. These are responsible for a variety of important effects: Stars get obscured by dust that forms further away from the stellar surface and that emits intense radiation in the infrared. The evolution along the asymptotic giant branch is terminated before the onset of carbon burning for initial masses up to 7 to $8\,M_\odot$, with remnant masses peaking at $0.6\,M_\odot$. During the transition from the red towards the blue the properties of the wind change drastically, viz. from a dust-driven wind with low speed and high density to a radiation-driven wind with high speed and low density. The interaction between these two wind types is important for the formation, shapening and further evolution of nebular shells.

To appear in Asymmetrical Planetary Nebulae, Annals of the Israel Physical Society, Vol. 11, eds. A. Harpaz and N. Soker *For preprints, contact* deschoenberner@aip.de

^{13}CO Interferometric Observations of the Central Core of CRL2688

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We report the results of mapping observations of a proto-planetary nebula CRL2688 in the ^{13}CO $J = 1 - 0$ line with a beamsize of $4''.4 \times 3''.8$ with Nobeyama Millimeter Array. Emission of ^{13}CO is extended by about $15''$, which is about one forth of the CO envelope size observed by single-dish telescopes. The channel-velocity maps show that CO emission consists of three components: an spherically symmetric high-brightness core at the center, a less bright extended envelope with clumpy structure, and a high-velocity component near the center. The high-brightness central core is found to extend by about $10''$ and to appear spherically symmetric. The

disk- or torus-like structure which was previously observed by others in several molecular lines is not seen in the ^{13}CO maps. This indicates that the gas density in the envelope does not vary much with the polar angle. The extended component is observed to spread along the symmetry axis. The peak positions of the red and blue-shifted features of the high velocity component are found to be separated by about $3''$.

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Dust formation in winds of long-period variables III. Dynamical models and confirmation of a dust-induced κ-mechanism

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We present self-consistent dynamical models for purely dust driven winds of C-rich AGB stars which are based on the coupled system of radiation hydrodynamics and time-dependent dust formation and growth. Investigating the dependence of the solution on the relative abundance of carbon to oxygen (i.e. the amount of condensable material) for several sets of stellar parameters we obtain stationary dust driven winds as well as solutions with periodic dust formation and creation of shock waves *without* applying a variable inner boundary to simulate a pulsation of the underlying star. Model series with certain stellar parameters show a transition from stationary winds to time-dependent solutions with discrete dust layers and shock waves as the carbon/oxygen abundance ratio exceeds a critical value. Summarizing the results, our calculations demonstrate that the limit case of stationary dust driven winds can be reproduced using the full, time-dependent code and furthermore provide an independent confirmation of the dust-induced κ-mechanism proposed by Fleischer et al. (1994).

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NaI and KI scattering in circumstellar envelopes: new detections around giants and the NaI λ5896/KI λ7699 line ratio

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We present new scattering measurements of KI or NaI in circumstellar envelopes, with the discovery of emissions around β Peg (M2.5II-III), ρ Per (M4IIb-IIIa) and CE Tau (M2Iab-Ib), expanding on previous detections to very low mass-loss rates (10^{-9} $M_\odot$ yr^{-1}). Supplementary data for α Ori and μ Cep, and upper limits for TX Psc, Y CVn, ρ Cas and BU Gem are also given. We homogeneously reanalysed the line surface brightnesses of the envelopes in order to consider the NaI λ5896/KI λ7699 line ratio. This ratio is found to be around 3, within a factor of 2, for the envelopes of μ Cep, α Her and o Ceti. It is considerably different for α Ori, in the sense that NaI is about 80 times too faint. CE Tau also seems to display a similar effect. Our analysis suggests that NaI interstellar absorption on the line of sight of Betelgeuse is the simplest explanation, though not completely convincing. Despite its location in the galactic plane, the NaI-emitting shell around μ Cep would not be so strongly affected by interstellar NaI owing to a favourable Doppler shift. If the Betegeuse NaI faintness is due to such an interstellar mutilation (and possibly also to envelope inhomogeneities and measurements errors), our observations strengthen the evidence for a low condensation of K and Na in oxygen-rich envelopes with moderate mass-loss rates (up to $\sim\ 2-4.\ 10^{-6}\ M_\odot$ yr^{-1}). We briefly examine other possible, although less probable, explanations like Na overabundance on μ Cep, or Na versus K differenciation, as found in comets.

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A survey of main−line OH maser emission from semiregular variables

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We have made a high sensitivity (∼0.15 Jy) search in the OH main−lines for maser emission from a sample of 181 semiregular variables. OH emission was observed towards five stars. Two new OH lines were detected and one tentatively. About 10% of semiregulars with distances less than 300 pc have associated OH maser emission. The OH semiregulars show much redder near and far infrared colors than similar non−OH stars. On the average, their mass loss rates and OH luminosities are slightly lower than in the long period variables. Basing on the optical and infrared properties of the semiregulars and long period variables we confirmed that properties of the SRa stars are intermediate between those of SRb and Mira variables. The occurrence of strongly polarized, low luminosity OH main−line maser only, together with relatively low efficiency of pumping by the infrared photons, provides evidence that the semiregulars are less evolved than the Mira−type variables. This can support the existence of an evolutionary sequence of SRb−SRa−Mira variables. However, the expansion velocities of some OH semiregulars are higher than those observed in most type I OH Miras and their pulsational properties may suggest that they are in a peculiar evolutionary phase.

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Morphology of Planetary Nebulae and its correlations with stellar evolution

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The different evolutionary paths that lead to planetary nebulae should be inferred from the nebular shapes and the observed characteristics of the central stars. The correlations between nebulae and stars are reviewed, from the origin of morphological classifications to the latest results, based on the most recent CCD narrow–band images of PNs. The latter results include some striking segregation of central stars hosted by morphologically different nebulae.

Invited review, to appear in Asymmetrical Planetary Nebulae, Annales of the Israel Phisical Society, Vol. 11, eds. A. Harpaz and N. Soker

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Red Giants with Unusual Dust Shells. II: The Dusty R-star HD100764

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We present an 8–13μm spectrum of the unusual, dusty early R-star HD100764. Contrary to earlier speculation this star does not have silicate dust around it, and is probably not directly linked evolutionarily to the controversial carbon stars with silicate dust features. The mid-IR spectrum, combined with existing optical and IR

photometry is used to model the dust around the star. We find that HD100764 must have a massive (3-5$M_\odot$) dust disk containing a distribution of grains ranging from small to very large, and that the observations are inconsistent with a spherical dust shell model. We argue that the most likely interpretation is that the star has acquired its dusty disk from a companion which has already evolved through the AGB and PN phases.

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Stellar evolution of low and intermediate-mass stars: II. Post-AGB evolution

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We present a set of evolutionary tracks for central stars of planetary nebulae in the range from 0.53 to 0.94$M_\odot$. These models are based on extensive stellar evolution calculations for initial masses between 1 and 7$M_\odot$ which have been carried out all the way from the main sequence through the AGB towards the stage of white dwarfs.

Concerning mass losses during the post-AGB evolution we smoothly reduced the high AGB mass-loss rates and then applied rates adapted from the radiation driven wind theory. The transition time from the AGB to the central-star region depends strongly on the treatment of mass-loss beyond the AGB.

Furthermore, our calculations indicate that massive central stars can fade much more slowly than hitherto assumed. It is shown that the fading time scales and the AGB history are closely connected, and that therefore the preceding mass loss on the AGB plays an important role for the post-AGB evolution.

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CS(2–1) Emission from Dense Gas in the Bipolar Outflow of CRL 618

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We have imaged the protoplanetary nebula CRL 618 in the CS(2–1) line at 98 GHz using the Owens Valley Radio Observatory millimeter interferometer with a synthesized beam of $\sim 2''.5$. For the first time, we have resolved the molecular core of CRL 618: the gas at the systemic velocity of the nebula is distributed like a cross, concentrated along two perpendicular linear structures. We have also detected emission out to the ends of the observing bandpass, which is at ± 170 km s^{-1}. The high velocity gas participates in a bipolar outflow, showing marked displacement with respect to the central source, with the redshifted gas generally to the West and the blueshifted gas to the East of the HII region. The spectrum of the CS line reveals a deep absorption feature that we have partially resolved.

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Post Doctoral Fellowship
Stellar Evolution and Nucleosynthesis
Monash University
Australia

Monash University has available a postdoctoral position in theoretical stellar evolution and nucleosynthesis. The appointment will be for 2 years initially, with excellent prospects for renewal for a third year. Salary will be in the range $AU36,793 - $AU39,495 per annum, and can start ASAP.

The position is part of a project investigating nucleosynthesis and stellar evolution, with particular emphasis on the Asymptotic Giant Branch phase. Experience in stellar struture, evolution, and nucleosynthesis is essential. Familiarity with spectroscopic obser- vational techniques would be an advantage, as it is intended to develop a vigorous and complementary observational program in coll- aboration with Australian and US observers. Interaction with other astronomical groups in Australia is strongly encouraged, including the staff and facilites of the Mt. Stromlo and Siding Springs Observatories, the Anglo-Australian Observatory and Telescope, the Australian National University's newly formed Astrophysical Theory Centre, and the Research Centre for Theoretical Astrophysics at the University of Sydney.

The appointment will be held within the Applied Mathematics section of the Mathematics Department, which currently houses seven theoretical astrophysicst staff members and ten graduate students. Current areas of research include: numerical hydrodynamics (SPH), star formation, stellar structure, solar physics, stellar dynamics, accretion discs (relativisitc and non-relativistic) and formation of the solar system. The Department has its own network of DEC Alpha computers, DECstations, and SGI computers. Time is available on the Fujitsu VP Computer and Connection Machine at the Australian National University Supercomputer Centre.

For those unfamiliar with Monash or Australia, Monash University is a large and progressive institution covering many campuses. The position will be held at the main campus in the south-eastern suburbs of Melbourne. Monash was named "University of the Year" this year by the independent "Good Universities Guide".

Melbourne is a sea-side city, located on the southern coast of Australia, and was recently named the world's "most livable city". It is a large (population 3 million) multi-cultural city with excellent cultural amenities. There are excellent beaches, National Parks and vineyards very close to the city.

Applicants should send a CV, list of publications, statement of research interests and at least three letters of recommendation by 27 January 1995 to the following address:

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