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Abstract of recently accepted papers

Sub-au imaging of water vapour clouds around four Asymptotic Giant Branch stars

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We present MERLIN maps of the 22-GHz H_2O masers around four low-mass late-type stars (IK Tau U Ori, RT Vir and U Her), made with an angular resolution of ∼15 milliarcsec and a velocity resolution of 0.1 km s^{-1}. The H_2O masers are found in thick expanding shells with inner radii ∼6 to 16 au and outer radii four times larger. The expansion velocity increases radially through the H_2O maser regions, with logarithmic velocity gradients of 0.5–0.9. IK Tau and RT Vir have well-filled H_2O maser shells with a spatial offset between the near and far sides of the shell, which suggests that the masers are distributed in oblate spheroids inclined to the line of sight. U Ori and U Her have elongated poorly-filled shells with indications that the masers at the inner edge have been compressed by shocks; these stars also show OH maser flares. MERLIN resolves individual maser clouds, which have diameters of 2 – 4 au and filling factors of only ∼0.01 with respect to the whole H_2O maser shells. The CSE velocity structure gives additional evidence the maser clouds are density bounded. Masing clouds can be identified over a similar timescale to their sound crossing time (∼ 2 yr) but not longer. The sizes and observed lifetimes of these clouds are an order of magnitude smaller than those around red supergiants, similar to the ratio of low-mass:high-mass stellar masses and sizes. This suggests that cloud size is determined by stellar properties, not local physical phenomena in the wind.

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Preprints can be obtained by contacting ib@star.herts.ac.uk or amsr@jb.man.ac.uk

A Radio Continuum Study of the 'Engraved Hourglass' Nebula, MyCn 18

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We present the first radio continuum images of the 'Engraved Hourglass' planetary nebula (PN) MyCn 18 from multi-frequency observations with the Australia Telescope. The radio emission is strongly core-dominated at all frequencies investigated. At the three higher observing frequencies, the radio emission is seen to trace the optically-visible hourglass lobes. In the highest resolution image, the position of peak radio brightness is found in a region which we show to be geometrically off-centre in the same sense as the offset of the 'central' star seen in the WFPC2 HST images of Sahai et al. (1999). The brightness temperatures measured are surprisingly low and this is interpreted as an effect of beam dilution and nebular clumpiness. We have attempted to separate the contributions to the integrated flux density from the lobes and the core and we present individual plots of the radio spectrum for these regions and also for the total nebular emission. These plots are used to obtain (lower, upper) limits to the turnover frequency of the core and the lobes, which in turn are used to derive (lower, upper) limits to the emission measure, density and ionized mass of the respective regions. Assuming the PN is at a distance of 2.4 kpc, we derive (lower, upper) limits to the total ionized mass of the PN of (0.2, 0.8) $M_{\odot}$.

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High Resolution Radio Structure and Optical Kinematics of NGC 7027

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We present the results of the highest resolution 18 cm (L-band) radio continuum and optical kinematic studies to date of the young planetary nebula (PN), NGC 7027. The radio image of NGC 7027 made from combined MERLIN+VLA data is discussed and used to derive the distribution of the nebular brightness temperature at this frequency. By combining the 18 cm image with the 6 cm (C-band) image of Bryce et al. (1997), two-dimensional distributions of spectral index between L- and C-bands, C-band optical depth and emission measure are constructed and analysed. In the optical regime, high dispersion, spatially resolved observations at high spectral resolution have been obtained of this PN. The resulting velocity ellipses confirm the inclination of the north of the PN towards the line-of-sight. A waist feature is seen in the equatorial plane and [S II]6716 Å / 6731 Å ratios indicate that a density enhancement exists in this region. The PN equatorial expansion velocity is deprojected and measured as 13 ± 1 km s^{-1} from the [O III]4959 Å emission line. This velocity is used to calculate a revised distance estimate of 650 ± 100 pc. Using the electron density derived from the [S II] ratio, an ionized mass of 0.005 $M_{\odot}$ is determined. The nature of the bright knot situated to the north-west of the PN is investigated at optical and radio wavelengths. In optical emission lines it is found to be redshifted. It is

located in the same region as the position of the peak flux density at 18 cm. It is shown that no evidence of a local density enhancement exists in its environs. It is suggested that the appearance of the knot is due to a temperature effect and its existence is interpreted in terms of a breach in the near side of the PN shell. The existence of a jet, at some stage in the evolution of the PN, is invoked to explain the mechanism by which such a breach may have been created.

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MERLIN Polarimetry of the OH Masers in OH17.7-2.0

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We report the first results of our study of magnetic fields in proto-planetary nebula candidates. Such fields may have important implications for the currently-accepted Generalised Interacting Stellar Winds path to planetary nebula formation. We present the first images of the 1612 MHz and 1667 MHz full polarization OH maser emission from the proto-planetary nebula, OH17.7–2.0, which were observed with MERLIN, at an angular resolution of 0.2 arcsec. We have detected one fully-resolved Zeeman σ-component pair at each observing frequency, from which we measure magnetic field strengths of $B = +4.6$ mG (1612 MHz) and $B = +2.5$ mG (1667 MHz). This is the first time a magnetic field strength has been measured in a proto-planetary nebula. The observations suggest a large-scale, regular magnetic field structure consistent with that of a stretched dipole field. When considered with near-infrared dust imaging polarimetry data, OH17.7–2.0 is shown to be a prolate spheroid, inclined at 20° to the sky plane, with the polar (major axis) outflow at a position angle of 20° in the plane of the sky and the denser equatorial axis at a position angle of between 110° and 120° in the same plane. The masers are shown to be contained in, and aligned with, this equatorial axis. There is additional 1612 MHz OH maser emission that can be associated with the interaction region between the fast wind from the post-AGB star and the remnant AGB shell. These data show that the stellar magnetic field can produce the necessary latitude-dependent mass loss on the AGB that is required in addition to the Generalised Interacting Stellar Winds models to produce ellipsoidal and bipolar planetary nebulae.

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Three-component modeling of C-rich AGB star winds I. Method and first results

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Radiative acceleration of newly-formed dust grains and transfer of momentum from the dust to the gas plays an important role for driving winds of AGB stars. Therefore a detailed description of the interaction of gas and dust is a prerequisite for realistic models of such winds. In this paper we present the method and first results of a three-component time-dependent model of dust-driven AGB star winds. With the model we plan to study

the role and effects of the gas-dust interaction on the mass loss and wind formation. The wind model includes separate conservation laws for each of the three components of gas, dust and the radiation field and is developed from an existing model which assumes position coupling between the gas and the dust. As a new feature we introduce a separate equation of motion for the dust component in order to fully separate the dust phase from the gas phase. The transfer of mass, energy and momentum between the phases is treated by interaction terms. We also carry out a detailed study of the physical form and influence of the momentum transfer term (the drag force) and three approximations to it. In the present study we are interested mainly in the effect of the new treatment of the dust velocity on dust-induced instabilities in the wind. As we want to study the consequences of the additional freedom of the dust velocity on the model we calculate winds both with and without the separate dust equation of motion. The wind models are calculated for several sets of stellar parameters. We find that there is a higher threshold in the carbon/oxygen abundance ratio at which winds form in the new model. The winds of the new models, which include drift, differ from the previously stationary winds, and the winds with the lowest mass loss rates no longer form.

Accepted by Astronomy & Astrophysics

Preprints can be obtained by contacting Christer.Sandin@astro.uu.se*or via WWW on* http://arxiv.org/abs/astro-ph/0211283

Detection of HCN Direct ℓ-Type Transitions Probing Hot Molecular Gas in the Proto-Planetary Nebula CRL 618

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We report the detection of direct ℓ-type transitions towards the proto-planetary nebula CRL 618 during a study of vibrationally excited carbon chains. The $J = 8, 10, 11, 12, 13, 14\ \Delta J = 0$ transitions of HCN in its first excited bending mode $v_2 = 1$ were detected in absorption against the continuum of the central H II region making use of the Effelsberg 100 m telescope and the Very Large Array. Additionally, the $J = 9$ direct ℓ-type transition was detected in emission presumably indicating a weak maser. All lines are blueshifted with respect to the systemic velocity of CRL 618 indicating that the lines originate from a hot, expanding circumstellar envelope. The HCN column density along the line of sight in front of the continuum is $2 \times 10^{18}\,\mathrm{cm}^{-2}$.

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Workshop announcement

Workshop on Evolved Stars - From AGB to PNe

We propose to hold a one day workshop on evolved stars, focussing particularly on evolution from the AGB to Planetary Nebula, to be held in the Department of Physics & Astronomy, University of Manchester, on Friday 31 Jan 2003. The workshop is aimed primarily, though not exclusively, at researchers in the UK and is organised through the UK working group on evolved stars. (http://www.astro.keele.ac.uk/e-stars/home.html)

There will be two sessions of talks (~15 mins each) and two open discussion sessions.

The number of participants will be limited to between 20 and 30. Please contact us if you wish to attend. If you would like to present a talk please could you give us a (rough) title to enable us to construct the programme.

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