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Abstracts of recently accepted papers

Hubble Space Telescope Observations of the Role of Planetary Nebulae in the Chemical Evolution of the Large Magellanic Cloud

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The latest Hubble Space Telescope results on the chemical evolution of Planetary Nebulae (PN) in the Large Magellanic Cloud (LMC) are given. It is shown that the results are consistent with the (mass-dependent) operation of the various chemical dredge-up processes predicted by theory. Dredge up of C appears to be most important during the thermal pulsing stage, and "hot bottom burning" transforms much of this C to N in the more massive stars. We show that the variation in the a-process element abundances can be understood as being due to the age: metallicity relationship for stars in general, and we derive, for the first time, the chemical history of the LMC using PN as tracers. There is clear evidence that a major burst of star formation occurred 2 Gyr ago, which almost doubled the base metallicity of the LMC.

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The spectral energy distribution and mass loss history of IRC +10420

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In this paper we present a study of the spectral energ distribution and mass loss history of the peculiar hypergiant IRC +10420. The results can be summarized as follows:

1. The spectral energy distribution of IRC +10420 has changed significantly over the last twenty years. While the V magnitude remained constant during this period, the (photospheric) J and K bands increased 0.75 magnitudes. We argue that the temperature of IRC +10420 has increased by about 1000 K.
2. Observations of the CO rotational transitions reveal complicated line profiles, where there is an excess emission at the blueshifted side of the emission lines. The red to blue asymmetry is found in many lines tracing different line forming regions, (Hα, SiO, OH) and suggests that the circumstellar envelope is slightly asymmetric over a large range of distances to the star.
3. The spectral energy distribution of IRC +10420 can not be fitted with one component. An additional hot dust component responsible for the observed excess emission at the near-infrared wavelengths was added to the model fit, giving satisfactory fits. The hot dust component is identified with a disk.
4. The mass loss rate of IRC +10420 as determined from the CO (1-0) lines and the model to the entire spectral energy distribution is found to be of order 5×10^{-4} $M_\odot$ /yr for a distance of 3.5 kpc.
5. We have presented evidence that IRC +10420 is not a post-AGB star. This is based on two arguments; firstly the observed high outflow velocities in CO can only be reached for the brightest possible post-AGB objects with extremely high dust-to-gas ratios. Secondly, the kinematic age of the inner radius of the cool shell, if IRC +10420 would be a post-AGB object, is too small to explain the fact that the V magnitude of IRC +10420 has remained essentially constant over the last 20 years, and the fact that the B magnitude brightened only by 1.4 magnitudes in the period between 1920 and 1978.

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Carbon stars with episodic mass loss: observations and models of molecular emission from detached circumstellar shells

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We have obtained detailed CO radio line maps of the circumstellar medium around the bright carbon stars R Scl, U Ant, S Sct, and TT Cyg. They provide direct evidence for the existence of large [radii between $10 - 70''$, or $(1-5)\times 10^{17}$ cm], geometrically thin (we estimate that the shell widths are $\leq 10''$), over-all spherically symmetric shells of CO line-emitting gas around these stars. The shells expand with velocities in the range 13-20 $\mathrm{km\,s^{-1}}$, i.e., their ages lie in the range $(1-10)\times 10^3$ years. Less extensive CO observations of the carbon star V644 Sco suggest that also it is surrounded by a detached shell. The expansion velocities of the present mass loss winds, as evidenced by weak CO emission from regions close to the stars, are considerably lower, of the order 5 $\mathrm{km\,s^{-1}}$. We conclude that the mass loss characteristics of these, otherwise apparently normal, carbon stars have changed significantly over the last 10^4 years. For such a shell structure, the most reasonable cause is a short period of very intense mass loss (i.e., a mass loss eruption), although an interacting-wind scenario cannot be excluded. The CO brightness distributions are very patchy, suggesting an inhomogeneous circumstellar medium.

Using a model where the shell consists of a large number of small, homogeneous clumps, we estimate that the H_2-masses of the four, spatially resolved shells are all around $0.01\,M_\odot$ (for an adopted CO abundance with respect to H_2 of $\approx 10^{-3}$), and that in the "mass loss eruption"-scenario the H_2-mass loss rates of the stars were $\approx 10^{-5} \times (10''/\Delta R)\,M_\odot\,\mathrm{yr}^{-1}$ during the formation of the shells (ΔR being the unresolved shell width in arc seconds). The present mass loss rates are very low, $\lesssim 10^{-7}\,M_\odot\,\mathrm{yr}^{-1}$. These results suggest that the four stars have all gone through a type of event that led to a dramatic change in the mass loss characteristics.

The adopted model is an initial, relatively crude, attempt to provide a more realistic base for the interpretation of line emission from a circumstellar medium in which, in general, the physical conditions are very likely quite inhomogeneous. It is the accidental overlap along the line-of-sight and in velocity space of the many small clumps that in the model produces a clumpy appearance of the brightness distribution, at the larger scale set by the observational resolution, that resembles the observed ones.

In the "mass loss eruption"-scenario the estimated life time of a CO line-emitting shell of the type discussed in this paper is $\approx 10^4$ years, and it is determined by the photodissociation of the CO molecules. Only shells younger than $\approx 10^3$ years are expected to be observable in molecular radio lines other than those of CO. There is a period after formation when such shells should be characterized by very anomalous line intensity ratios. For instance, in our model the line intensity ratio between the photodissociation product CN and the parent molecule HCN increases drastically on a time scale of hundreds of years as the shell recedes from the star. We suggest that the shell around R Scl is in this phase, since this is the only object, among the five observed, in which we have clearly detected also lines of HCN and CN, albeit with anomalous line intensity ratios.

Accepted by Astronomy & Astrophysics *Preprints can be obtained by contacting* hans@astro.su.se

Optical observations of planetary nebula candidates from the northern hemisphere

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We present Hα+[N II] images of 17 and low resolution spectra of 14 IRAS-selected planetary nebula candidates. The Hα+[N II] images are presented as finding charts. Contour plots are shown for the resolved planetary nebulae. From these images accurate optical positions and mean optical angular diameters were determined. Optical spectra show that the IRAS-selected and radio detected planetary nebula candidates are indeed planetary nebulae. Three planetary nebula candidates, previously not detected in the radio continuum were seen in Hα. They are larger, low surface brightness planetary nebulae. Most of these IRAS planetary nebulae are heavily extinct, having an average A_V of 7 magnitudes. About half of the planetary nebulae seem to be of low excitation, having central stars with an effective temperature probably $\sim$60,000 K or less.

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Preprints can be obtained by contacting gsteene@eso.org

Structure of the Molecular Envelope of CRL 2688 Based on the ^{13}CO Observations

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We have studied a proto-planetary nebula CRL 2688 by mapping observations in the ^{13}CO $J = 1-0$ line. Data obtained by single-dish (Nobeyama 45-m) and interferometric (Nobeyama Millimeter Array) observations are combined and reduced into maps of the whole flux of ^{13}CO emission in the envelope. The resultant maps reveal that weak ^{13}CO emission is extended by about $20''$ (corresponding to 3×10^{17} cm) from the central star. Part of the extended emission spreads towards the south of the source, although no counterpart is seen in the north. The mass of this component is estimated to be about 0.08 solar mass. Numerical model analyses of

the velocity-channel maps are performed to obtain a three-dimensional density distribution in the envelope. They indicate that the mass-loss of the central star was drastically increased about 3000 yr ago, reached at the maximum rate of about 3×10^{-4} solar mass per year, and then abruptly stopped approximately 200 yr ago. The present ^{13}CO observations show no evidence for the presence of a large axisymmetric disk in the bright core region. The disk, which is inferred from the shape of the bipolar reflection nebula at the optical and near-infrared wavelengths, may be very small, less than a few arcsec, in size. It is suggested that the high-velocity flow detected in the ^{13}CO interferometric observations originates from the gas in the thick envelope heated by the shock with collimated outflows.

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Preprints can be obtained by contacting deguchi@nro.nao.ac.jp

Interferometric molecular line observations of the circumstellar envelope(s) around U Camelopardalis

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We have observed the circumstellar envelope of the carbon star U Cam in the HCN($J=1\rightarrow 0$) and CN($N=1\rightarrow 0$) lines using the IRAM Plateau de Bure interferometer. There is evidence of a two-envelope structure: an outer extended envelope, possibly a shell, with a radius of $\approx 7 \times 10^{16}$ cm, that expands with a velocity of $\approx 25\,km\,s^{-1}$, surrounding an inner envelope with a radius of $\approx 6 \times 10^{15}$ cmand an expansion velocity of only $\approx 13\,km\,s^{-1}$. Mass loss rate estimates based on these data alone are uncertain, but they suggest that the mass loss rate during the formation of the outer envelope was higher than during the present mass loss epoch. Thus, we have evidence for a significant variation in the mass loss characteristics of U Cam within the last 10^3 years.

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Mass Loss in AGB Stars

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The envelopes expelled by AGB stars are probably the best sites for testing the theories of Stellar evolution and Astrochemistry. While the matter is expelled from the stellar atmosphere and expands in outer space, it encounters a wide range of physical and chemical conditions. About every molecule formation/destruction mechanism may at some point proceed, resulting in an exceptionally rich chemistry. Since the velocity field and geometry of circumstellar envelopes are relatively simple, these objects are unique laboratories of time-dependant chemistry. For a long time, the large visual extinctions and small angular sizes have empeded the observation of high mass loss objects. The development of mm and IR interferometry has allowed a breakthrough in this domain. Molecules and dust are now routinely mapped at arcsecond resolutions, providing a large data basis to which the model predictions could be confronted.

The newest data obtained on the carbon star IRC+10216 and the PPN CRL 618, with the IRAM interferometer and 30-m telescope, are presented and compared to model predictions, with emphasis on density/velocity structures and on envelope chemistry.

I.A.U. Symp. 170 (Invited review)

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Announcement

A Supplement for the "Strasbourg-ESO catalogue of planetary nebulae"

In the framework of the Symposium 180 (Groningen, August 1996), we plan to prepare a Supplement of our catalogue published 4 years ago. In order to collect all available data in all spectral ranges, concerning new PN or possible PN, inside our galaxy and other galaxies, we would appreciate getting your recent results (reprints, preprints, thesis extracts, internal notes,..) to my postal address : Acker Agnes, 11 rue de l'Universite, 67 000 Strasbourg (France) or by fax : (33) 88 35 14 08 or by e-mail : acker@simbad.u-strasbg.fr

Thank you for your collaboration.

Agnes Acker