this will allow a detailed study of the outer layers of this bright supergiant. Other occultations were recorded, showing the possibilities and the limits of the 3.6-m telescope in this mode of operation.

But what seems more important to us is the fact that the feasibility of lunar occultations at La Silla has now been demonstrated, and that the results are of the best quality. If lunar occultations were observed on a routine basis at La Silla, maybe taking advantage of future developments of the remote-control facility, a relatively large number of new diameter determinations could be easily collected. This would help to gain new knowledge about the calibration of fundamental quantitities of cool stars and probably lead to the discovery and the study of circumstellar dust shells and binary systems. There is no doubt that the angular resolution of the present method is superior to all other techniques at least in the infrared.

5. Acknowledgements

Our work would not have been possible without the help of many people before, during and even after the observations. In particular, we are grateful to P. Bouchet, U. Weilenmann and the infrared technical staff at La Silla, to C. Perrier for his help during one whole night with the specklegraph, to F. Gutierrez and S. Vidal for their help with the Fast Photometry software, to the night assistants R. Vega and H. Herborn.

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The Large Intractable Nova Shells

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Despite the fact that nova outbursts seem to be well understood – at least in principle –, the fine structures of the eruptions remain enigmatic. Novae are believed to be binary stars, composed of a white dwarf and a tightly bound cool dwarf secondary which dumps unprocessed material onto the surface of the primary at a rate of 10^{-8} $M_\odot$ per year, i.e. 600,000 million tons per second. After perhaps thousands of years – the order of magnitude is still uncertain – enough material has accumulated on the surface of the white dwarf to give rise to a thermonuclear runaway in the electron-degenerate, hydrogen-rich layer. The accreted matter plus some carbon-oxygen-rich white dwarf material, which was mixed into it during the accretion process, is partially processed in the CNO cycle, and, over a time interval of weeks to years, ejected into space with a speed of several hundred to a few thousand km/s. Thus the nova shell is formed.

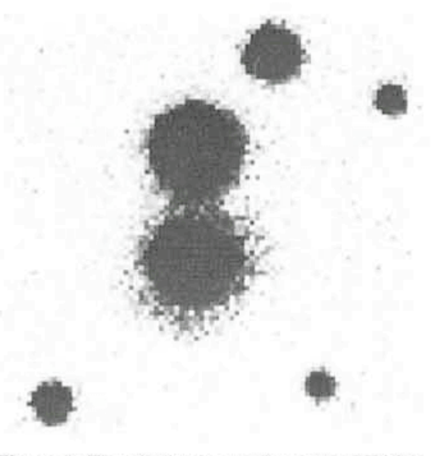

Figure 1: *The shell surrounding nova BT Mon, taken through an Hα filter.*

Faithfull readers of the *Messenger* may still remember the report on the discovery of shells around southern novae *The Messenger* No. 17, June 1979, page 1). In that article, photographs of the shells of RR Pic, CP Pup and T Pyx, taken at the prime focus of the ESO 3.6-m telescope, were presented. In early 1987 a combined study, based on imaging and spectroscopy with the ESO 2.2-m telescope, helped to illuminate more facets of nova remnants and their evolution. We even added a new nova nebula to the small list of known objects. The shell of BT Mon, which erupted in 1939, was first postulated from spectroscopic evidence (Marsh et al. 1983). Now it is seen in Figure 1, very weak and with a nearly circular outline.

The determination of shell properties of novae: geometry, kinematics, temperature, density, and chemical composition as functions of space and time is a largely unsolved task. The variety of light curve types for different nova outbursts reflects to some degree the temporal behaviour of mass ejection. However, almost nothing is known about the late phases of the outburst and the transition to a quiescent wind from the central object.

Spectra taken during the nova outburst display emission lines whose structures indicate that matter is generally not ejected in simple spherical shells. The absorption lines show that gas clouds given off at later times have higher velocities than those of the principal mass ejection. The high velocity material must interact with the previously ejected clouds. Estimates of the times, after which clouds of different velocities meet, agree well with the times at which certain ionized species are first observed in the spectra. The kinetic energies which might be transferred during inelastic collisions have just the right values to account for the observed ionization stages. The appearance of high excitation ("coronal") emission lines in the spectra of some novae during late stages might be attributed to the interaction of the highest velocity material with the principal shell. But is all high-velocity material decelerated by collisions, or can we still observe some of it?

Combining several CCD frames of a

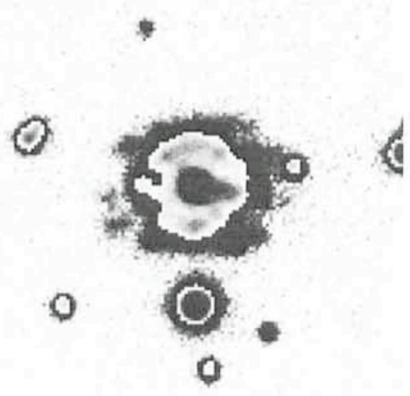

Figure 2: *The shells surrounding the recurrent nova T Pyx, taken through an Hα filter. For this composite, the central section of the highly amplified picture was set to zero, then a lower amplification image of the well-known central nebula was inserted.*

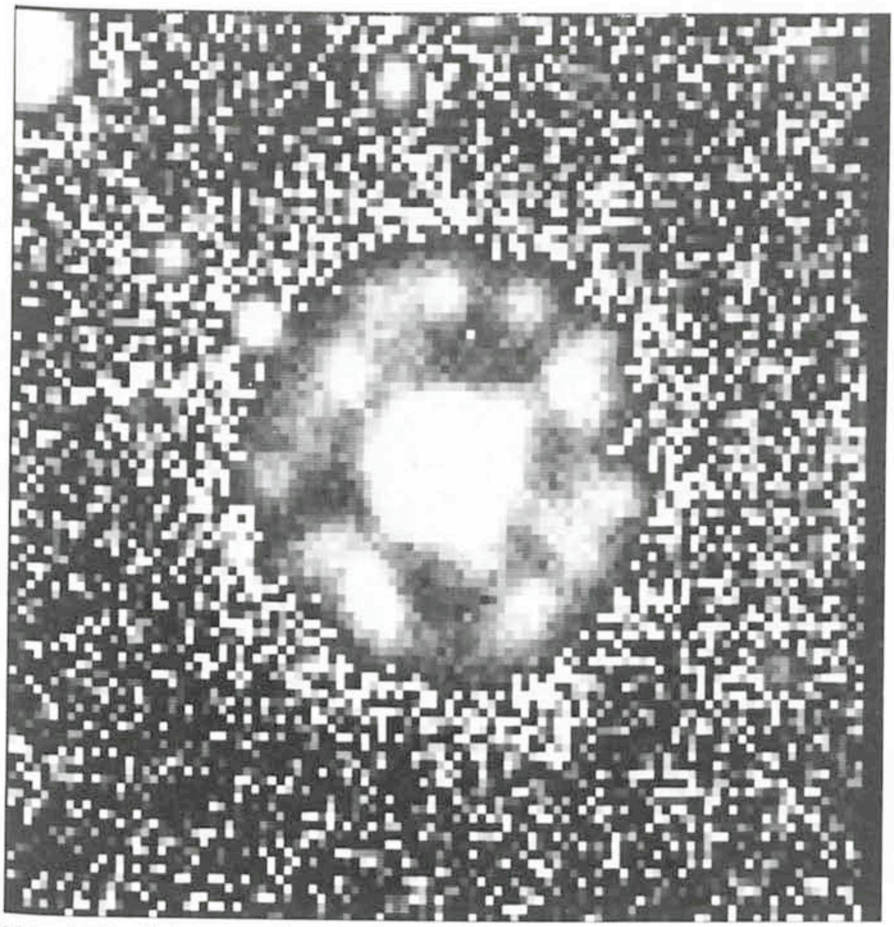

Figure 3: *The shells surrounding nova CP Pup, taken through an Hα filter. Composite picture as in Figure 2.*

nova shell is a powerful tool to make faint nebulosities clearly visible. Before turning to the questions asked above, we present an object, where we expect a superposition of shells: the recurrent nova T Pyx. This slowest one of the few known recurrent novae (V 394 CrA, T CrB, RS Oph, T Pyx, U Sco, V 1017 Sgr) had recorded outbursts in 1890, 1902, 1920, 1944 and 1966/67, the frequency of which lets us expect a new eruption very soon.

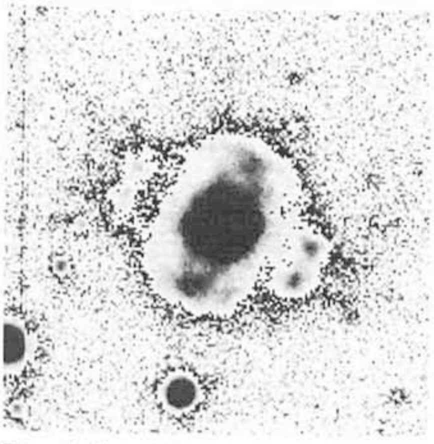

Figure 4: *The shells surrounding nova RR Pic, taken through an Hα filter. Composite picture as in Figure 2.*

Faint shells are barely apparent on a single CCD exposure (Seitter 1987). A clearly visible secondary shell was found on several superimposed images. In Figure 2, the central section of the highly amplified picture was set to zero, then a lower amplification image of the well-known central nebula was inserted. The tenuous outer shell can be attributed to the 1920 outburst, the central shell to that of 1944 while the shell of 1966/67 is still too close to the star to be resolved.

In contrast to the multiple shells from multiple events, secondary shells around classical novae must be attributed to different phases of a single event. The fast nova CP Pup, which erupted in 1942, exhibits a halo of weakly glowing gas around a stronger inner nebulosity (Fig. 3). So does the slow nova RR Pic, which appeared in 1925 (Fig. 4). In both cases the outer structures have some resemblence with the inner ones. In CP Pup both shells are circular, the ratio of their radii is 1.7. In RR Pic the outer shell is by factors 1.6 to 1.9 larger than the nebulosity found earlier and depicted in the photographs of Messenger No. 17. Interaction of the halo material with the "polar blobs" is suggested by long filaments apparently originating in the blobs and extending outward in radial directions.

From the absorption spectra of RR Pic observed during outburst it is known that the ejection velocities of the "diffuse enhanced stage" are 1.5 to 2.2 times larger than those of the earlier principal ejection. Material lost during

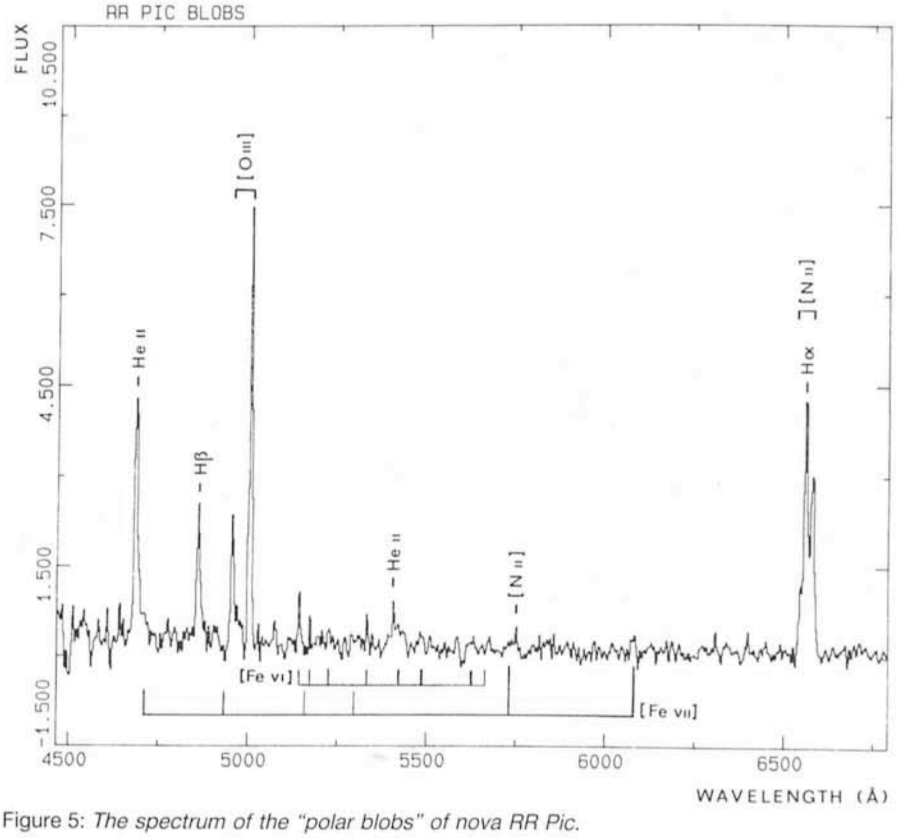

Figure 5: *The spectrum of the "polar blobs" of nova RR Pic.*

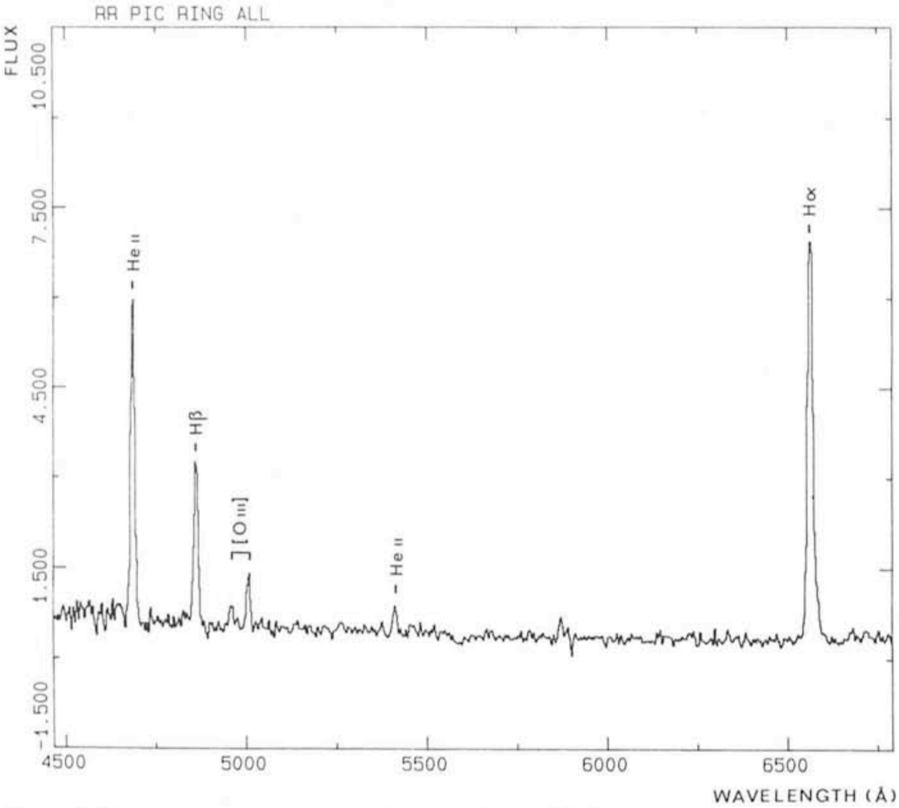

Figure 6: *The spectrum of the "equatorial ring" of nova RR Pic.*

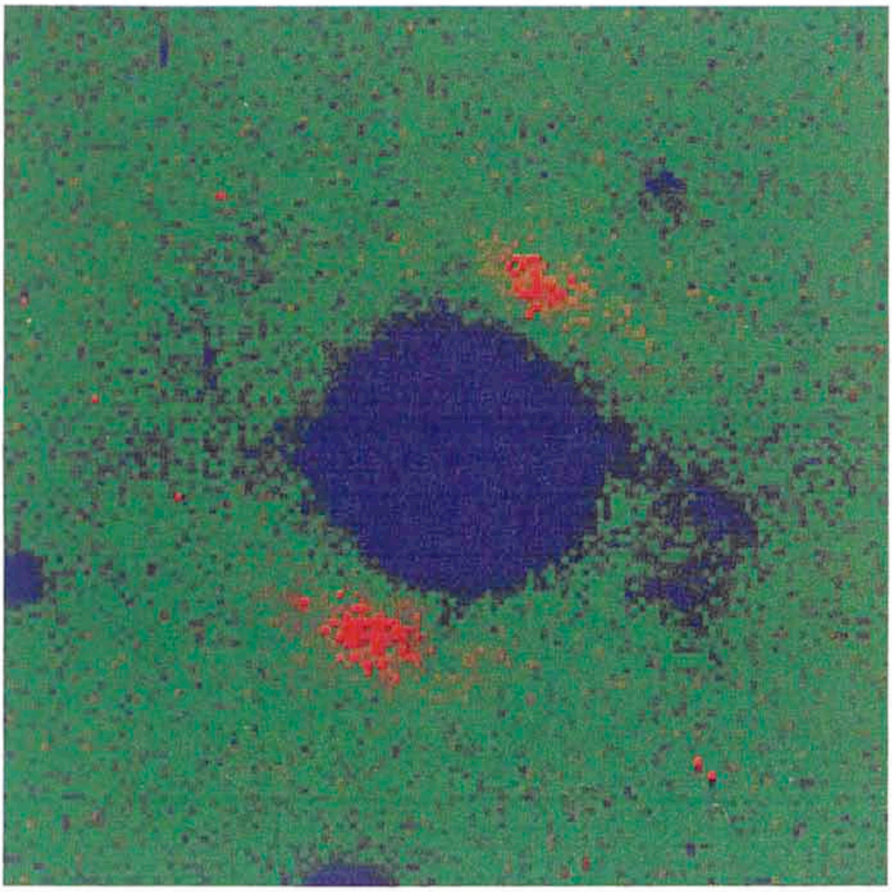

Figure 7: *Mapping of the chemical inhomogeneities in the shell of nova RR Pic. Regions with relatively higher contributions of [O III] are blue, those with relatively higher contributions of [N II] + Hα are red. The stellar colours are determined by continuum radiation and are not correctly shown in the chosen colour table.*

the still later "Orion stage" is 3.5 times faster. As a working hypothesis, we adopt the notion that the halo is made of diffuse enhanced material, which penetrated the principal shell and whose interaction with gas condensations in the principal shell led to its present filamentary appearance.

In CP Pup the ratio of the diffuse enhanced to the principal velocity is 1.2 to 1.6, but since the velocity of the principal absorption increased noticeably during the early stages of the outburst, it is not clear whether the diffuse enhanced mass outflow or the material ejected during the late stages of the principal phase is responsible for the halo.

In order to obtain information on local physical parameters, spectra taken in different parts of a shell are required. The CCD spectra of RR Pic from the recent observing run have considerably higher S/N ratio than earlier IDS spectra. They reveal more lines so that the parameters can be determined with better confidence (Figs. 5, 6). Even lines from the inner regions of the outer shell are visible in the CCD frames. These lines suggest that the physical conditions are similar to those in the inner shell, except for the density.

Newly found features are several weak lines of [Fe VI] and [Fe VII], found only in the polar blobs. Lines of [Fe V] were reported in the blue spectra of the blobs by Williams and Gallagher (1979). The same highly ionized iron lines were observed in the late decline from outburst (1926–1934) where we consider them to be the spectral tracers of ionizing collisions between high velocity particles and low velocity shells. In the well developed shells tens of years after outburst, the source of excitation could be a hot wind. Coming from the accretion disk, it streams mainly vertically away from the disk which is assumed to lie in the plane of the "equatorial ring".

In the spectra of two polar blobs, the electron temperature derived from the strength of [N II] lines is 35000 K. The ratio He II/Hβ is the same in the polar blobs and in the equatorial ring, suggesting similar temperatures for the two regions. In the spectra of the equatorial ring, marginal [S II] lines give values for the electron density of 10 to 100 cm^{-3}. These lines are not visible in the polar blobs. Because of the brightness of the blobs it is, however, hard to assume that the electron densities are much lower. Finally, the ratio of line strengths [O III]/[N II] is 2.5 in the blobs and approximately 1 in the rings. This strongly suggests a difference in chemical composition of the two regions. At first sight, it seems more likely that the enhancement

Figure 8: *Mapping of the chemical inhomogeneities in the shell of the recurrent nova T Pyx. Colour coding as in Figure 7.*

of oxygen in the polar blobs is due to meridional circulation of white dwarf material at the onset of the outburst (Kippenhahn and Thomas 1978) than to differences in the ashes of nuclear burning.

The apparent abundance inhomogeneities can be mapped by combining pictures taken through interference filters isolating the radiation of [O III] and [N II] + Hα, respectively. In the colour plots, regions with relatively higher contributions of [O III] are blue, those with relatively higher contributions of [N II] + Hα are red (Figs. 7, 8).

Aside from their physical meaning, which must still be better substantiated, the colour plots help to determine the symmetry axes in nova shells. This was already shown for the northern nova GK Per (Duerbeck and Seitter 1987) which until then was considered irregular. The shell of RR Pic is shown in Figure 7. The colour method is particularly useful for shells which appear in nearly spherical projection, such as T Pyx (Fig. 8).

This ends our present report on nova shells. With a plethora of novae and nova remnants still awaiting their observational share, the field of stellar cataclysms appears to be as attractive as ever.

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Internal Dynamics of the Gum Nebula

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Introduction

Among the many large and spectacular objects of the southern sky, the Gum nebula with an angular diameter of 36 degrees in the sky is the object with the largest known apparent dimensions. Unlike the other large objects like the Large Magellanic Cloud (diameter ≃ 8°) and the Small Magellanic Cloud (diameter ≃ 3°) which clearly stand out as highly luminous regions in the night sky, the Gum nebula, however, is extremely faint and is not visible to the naked eye. The only way to see this nebula is to look at the photographs taken in emission lines like H_α λ 6563 Å and [NII] λ 6584 Å lines since the entire visible radiation from the nebula is confined to a few such emission lines. But the extent of the nebula is so large that it fills the conventional Schmidt photographs and can be detected only from a mosaic of Schmidt photographs. In fact, the nebula was first detected this way in 1953 by Colin S. Gum, who made a mosaic of several long exposure Schmidt plates of this region, each with an 11° field, taken in the H_α + [N II] lines. It is befitting that the nebula now bears the name of its discoverer, C.S. Gum, who was unfortunately killed in a skiing accident in Switzerland in 1960, at a relatively young age of 36.

The central region of the Gum nebula contains Zeta Puppis (O4f), the brightest O-type star in the sky, and Gamma Velorum (WC 8 + 09 I). From the ESO IIa-O and the SERC IIIa-J plates of the region of the Gum nebula, about 29 cometary globules (CGs) and 7 dark clouds have been identified (Hawarden and Brand, 1976, Sandqvist, 1976, Zealey, 1979, and Reipurth, 1983). Cometary globules are dark clouds which have dark, dense heads which are completely opaque to the background starlight, and faint, luminous tails through which background stars can be seen. The heads often have bright rims on the side that points towards the centre of the Gum nebula complex while the tails, in general, point away from this central region. To date, a total of about 38 CGs have been noted and catalogued of which 29 lie in the Gum nebula region. Several of these