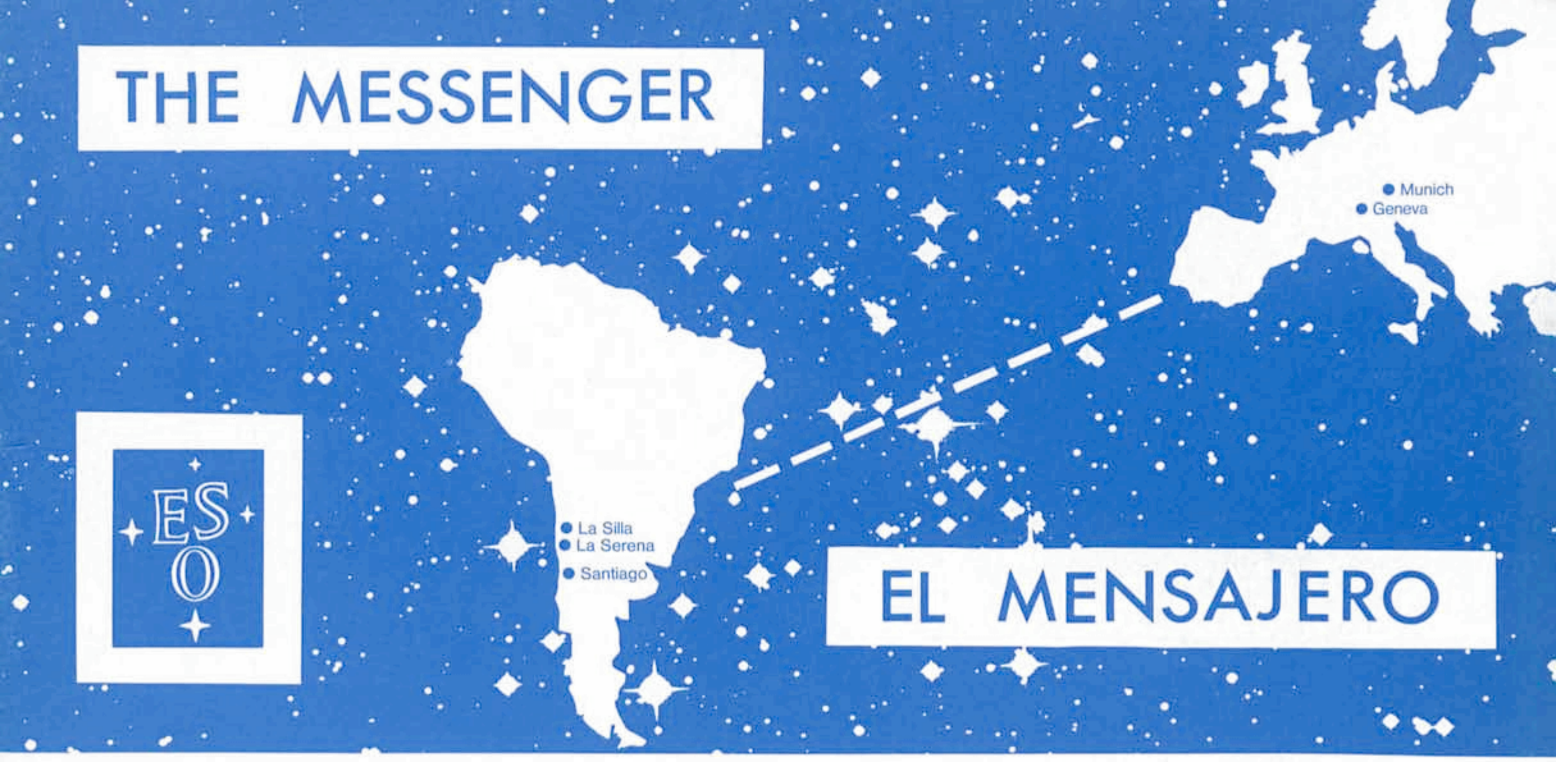

No. 17 – June 1979

Shells Around Southern Novae

H. W. Duerbeck and W. C. Seitter

Although less spectacular than their big brothers, the supernovae, the novae *are by no means less interesting. They are also much more frequent and several are known in the southern sky. After the initial explosion, a shell expands around the nova and may become visible after a while. Drs. Hilmar Duerbeck and Waltraut Seitter from the Hoher-List Observatory, near Bonn, FRG, recently observed three southern novae. The excellent resolution of the 3.6 m photos makes it possible to see details in the very faint nova shells that have never been perceived before.*

The southern sky comprises one of the most fanciful supernova remnants—the extended spider web of the Gum nebula. It harbours also some less spectacular, tiny, astronomically shortlived phenomena: the remnants of near nova explosions. They can be observed for only a few decades after outburst, before they thin out and merge into the interstellar medium. Due to their small size and low surface brightness, they require large telescopes, such as have recently become available in the southern hemisphere. Fortunately, some observing time was granted to us before the above-mentioned disappearances!

RR Pictoris

Two brilliant novae shone in the southern sky in this century. The first one, RR Pic, was discovered on May 25, 1925, and reached its peak magnitude of $1\overset{\text{m}}{.}2$ on June 9. It remained visible to the unaided eye for about a year. Spencer Jones published in 1931 a bulky volume of spectroscopic and visual observations made at the Cape Observatory. Another southern observer, J. Hartmann in Buenos Aires, observed the nova spectroscopically and wrote the most concise astronomical paper ever published, a telegram sent to the *Astronomische Nachrichten:* "Nova problem solved; star blows up, bursts." And indeed, when double-star observers examined the postnova two

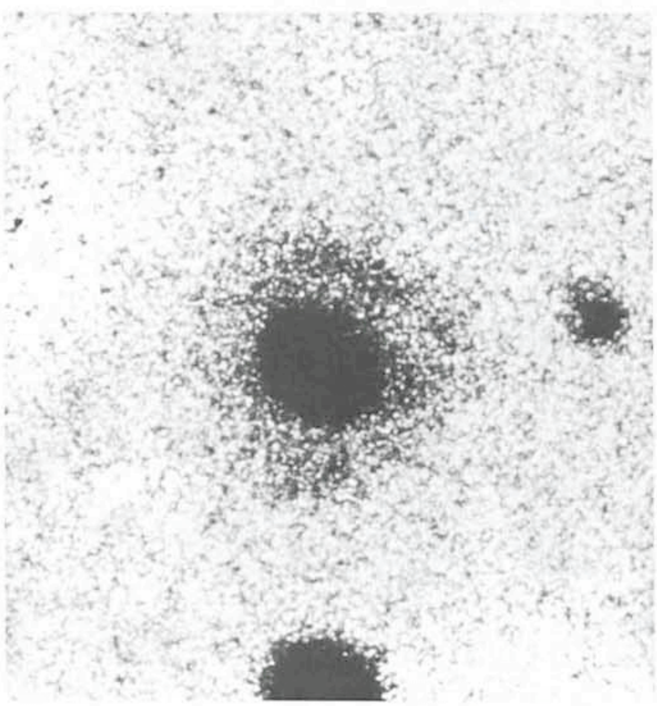

Fig. 1: *The nebular shell around T Pyx (1966). From a prime focus 098 plate behind a RG 630 filter, exposure 70 min.*

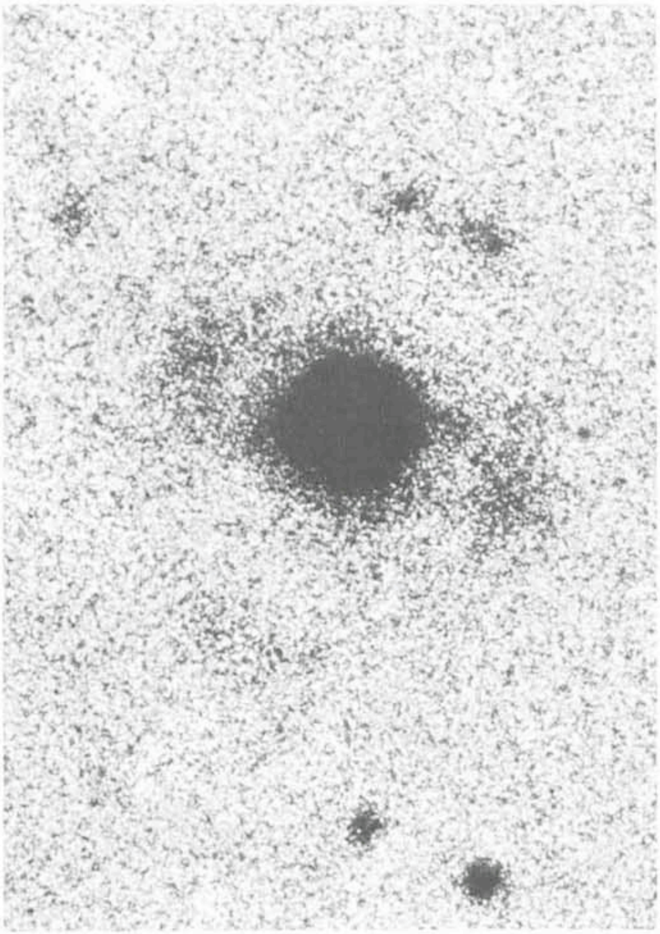

Fig. 2: *The nebular shell around RR Pic (1925). From a 3.6 m prime focus 098 plate behind a RG 630 filter, exposure 90 min.*

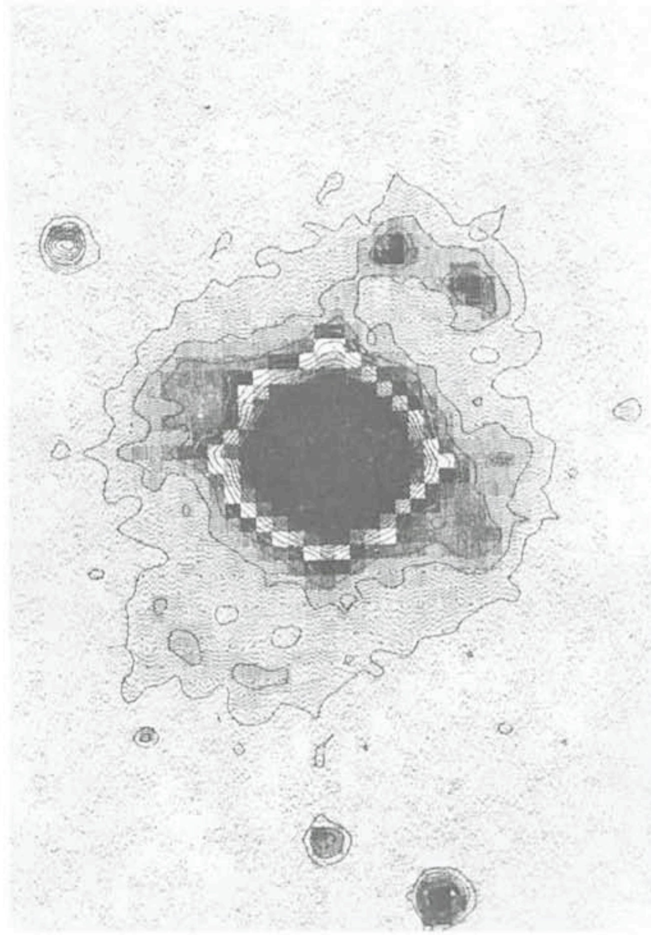

Fig. 3: *The nebular shell around RR Pic (1925). From a prime focus III a-J plate behind a BG 385 filter, exposure 60 min. Plot prepared from PDS density scans.*

years later, it was embedded in a nebula, with two distinct concentrations moving in opposite directions. We quote: "1928.284. Nebula slightly elongated in 250°±. Does not merely look double; looks granular and separated by patient watching. AC 253°±, AB 124°±, AD 353°±. × 810. In my opinion, A, B, C certain, D somewhat doubtful . . ." (Spencer Jones 1931).

Have a look at the appearance of RR Pic on a 90^m red exposure, taken at the prime focus of the ESO 3.6 m telescope (fig. 2). The postnova is surrounded by a structured nebulosity. A ring-like feature encompasses the central star, two pairs of condensations seem to have been ejected with higher (tangential) velocities, at right angles to the ring and opposite to each other. They can easily be identified as fragments B and C of the early double-star observers. A is, of course, the central star, and D part of the ring-like structure. The computer-enhanced, blue image is shown in figure 3.

RR Pic resembles the well-known remnant of Nova DQ Her, which also displays an "equatorial ring" and "polar blobs", but it has a more complicated structure: the polar blobs are double or even triple, and there are two equatorial rings, inclined to each other, and each nearly perpendicular to an axis joining prominent polar condensations. The similarities between DQ Her and RR Pic are striking: both are slow novae, both are short-period binaries (Walker 1954, Vogt 1975), both nebulae show the same basic geometry.

An important, and in principle straightforward, use of a nova remnant photograph is the determination of the nebular parallax: with the known expansion velocity of the shell in km s^{-1}, as observed during outburst, and the dimensions of the shell in arc seconds at some later time, the distance can be determined without any further assumptions. But alas! RR Pic showed many radial velocity systems in the course of its evolution, ranging from 40 to 1,600 km s^{-1}, and the shell has many diameters: that of the ring, that determined by the blobs, or merely, the projection of the blobs in the sphere, since the open ring structure indicates that the polar blobs are not ejected perpendicular to the line of sight. A preliminary analysis leads to a distance of 400 pc. This is a slight revision of the previously assumed value.

CP Puppis

The nova with the fastest development, except V 1500 Cyg 1975, is CP Pup of 1942. Observed expansion velocities were of the order of 1,200 km s^{-1}. High-resolution spectra obtained in the later nebular stage by Sanford (1945) showed Hβ and [O III] 4364 broken up into more than a dozen emission components.

Zwicky, in 1955, obtained a practically featureless photograph of the shell with the Palomar 5 m reflector. When he published the photograph in 1962, he wrote: ". . . it would merit greater attention than it has been accorded hitherto and it is to be recommended for more observations particularly to observers in the southern hemisphere . . ." Here it is (fig. 4): A fringed halo on the blue plate, a chain of black pearls on the red plate: a late confirmation of the early fragmented emission line profile? Again it must be said that a straightforward application of the nebular expansion parallax is not possible, but if it is assumed that the major portion of the material was ejected in a slightly inclined ring, data from the spectroscopic study and the direct photograph can be reconciled. The derived distance of 1,500 pc is in excellent agreement with an earlier determination, based on galactic rotation and interstellar lines, and leads to a very high peak brightness of $M = -11^{m}.5$. CP Pup was very likely the most luminous nova observed until now.

T Pyxidis

The third remnant, the nebulosity around the recurrent nova T Pyx, was in some respects a surprise. Recent photographs of the brightest recurrent nova, T CrB, had revealed only very weak nebular whisps (Williams 1977). The very strong nebulosity around T Pyx is thus unusual.

Again it is not trivial to derive the nebular parallax. Radial velocity observations are scarce for T Pyx and we find the added problem of having to decide which outburst caused the remnant. Was it produced in 1966, 1944, 1920, 1902, or even 1890?

Fortunately, Catchpole (1969) provides us with the knowledge of a radial velocity system observed in 1966 of $v = -900$ km s^{-1}, interpreted as being due to the principal spectrum. With this, a distance of 600 pc is deduced, corresponding to absolute magnitudes at maximum of $M_v = 2^{m}.9$ and at minimum of $M_v = +4^{m}.4$. Under the above assumptions, the recurrent nova does not fit into the t_3—absolute magnitude at maximum—relation.

It is possible to check on the 1966 origin of the shell. With the distance and the angular diameter known, the volume enclosed by a spherical nova shell and its content of interstellar matter can be deduced. Assuming that the detection of a shell requires its density to be 10–100 times the interstellar density, we find that a 1944 shell must contain at least 10^{28}–10^{29} g of matter and, with a suspected higher expansion velocity of 1,700 km s^{-1}, even 10^{29}–10^{30} g, while a shell ejected in 1966 has a lower mass limit of 10^{27}–10^{28} g. The former values seem rather too large, especially in view of earlier determinations for other recurrent novae which yield 10^{28} g or less. It must be kept in mind, however, that the above argument requires spherical volumes. Thin shells or remnants with strong condensations combine smaller ejected masses with longer lifetimes.

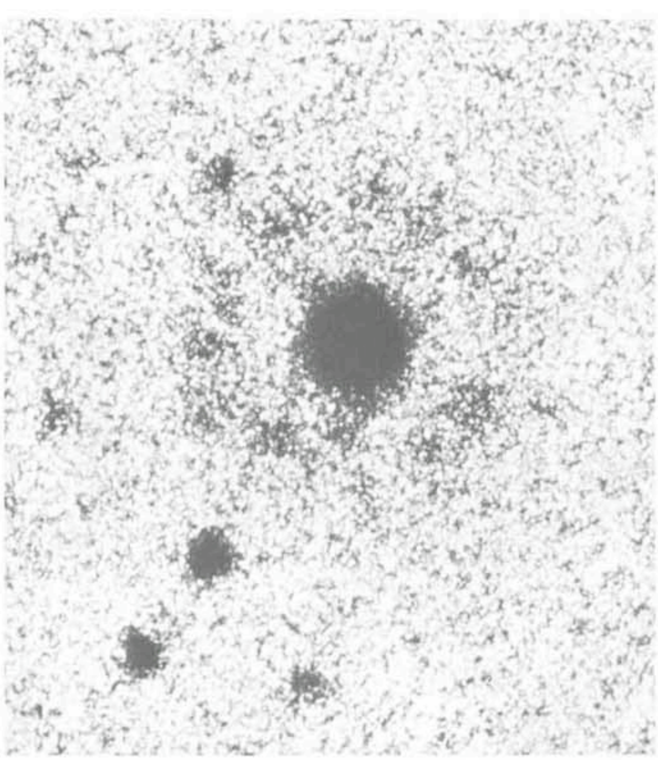

Fig. 4: *The nebular shell around CP Pup (1942). From a prime focus 098 plate behind a RG 630 filter, exposure 60 min.*

Perhaps the strongest argument in favour of a 1966 shell is the absence of strong remnants of earlier outbursts, possible proof of a short lifetime, as well as a more spherical nature of recurrent nova shells.

While all arguments are weak, they provide us with a comfortably complete set of data for a 1966 outburst. With the implied fast development of the remnant it is easily possible to verify or to reject our conclusion by systematically following the future development of the remnant of T Pyx.

The photographic investigations reported here are clearly only the beginning of a closer study of nova remnants and must be supplemented by spectroscopic investigations which will permit a closer look at the physics of the nova shell and hopefully shed more light on the nature of the nova process.

We are pleased to thank the night assistant of the ESO 3.6 m telescope, Sr. Yagnam, for most efficient handling of the telescope and the coffee machine, and Dipl. phys. H. J. Becker (Bonn) for his readiness to produce beautiful plots from PDS scans.

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