integration time was $1^h30^m$. The signal-to-noise ratio, for the continuum is of the order of 20 corresponding to an effective magnitude of the order of 8.5 (see for instance the S/N ratio values as a function of the V magnitude given by D. Enard (1981) essentially due to the emission lines).

The spectrum is shown in Fig. 1. Profiles of both [S II] lines at 6717 and 6731 Å appear double; the separation of the two peaks corresponds to an expansion velocity of the shell of 30.3 km $s^{-1}$. This value is in good agreement with the result obtained from [N II] line observation by Osterbrock (1970).

Let us call $I_{1B}$ and $I_{1R}$ the blue and red shifted components of the [S II] line at $\lambda = 6717$ Å, $I_{2B}$ and $I_{2R}$ the corresponding components of the [S II] line at $\lambda = 6731$ Å. A cursory examination of the line profiles permits the following comments:

(1) The ratios $I_{1B}/I_{2B} = 0.58$ and $I_{1R}/I_{2R} = 0.56$ show that both recessing and approaching parts of the expanding shell have similar electron density.

(2) The widths at half-maximum of $I_{2B}$ and $I_{2R}$ have the same order of magnitude ($\Delta\lambda \sim 0.45$ Å); therefore, it may be expected that the corresponding parts of the expanding shell have similar thickness.

(3) The ratios $I_{1B}/I_{1R} = 0.84$ and $I_{2B}/I_{2R} = 0.80$ are also quite similar. Taking into account the previous comments, this indicates that the abundance ratio of $S^+$ ions in the recessing (R) and approaching (B) parts of the expanding shell is of the order of 0.8. This may be due to a non-symmetrical ionization structure of the nebula as suggested by Osterbrock (1970) from other considerations.

## Conclusion

So far, it is the first time that the planetary nebula IC 418 is observed with a spectral resolving power as high as $10^5$. Both [S II] lines at 6717 and 6731 Å show well separated components corresponding to a "classical" expanding shell. Density and thickness of both parts of the nebula observed on the central line-of-sight are quite similar. However, the $S^+$ concentration seems larger in the farther (recessing) part of the shell than in the nearer (approaching) part. This is certainly due to a non-symmetrical ionization structure of the shell.

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# The Fate of Dust Grains in a Shock Wave Originated by a SN Explosion

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Observations of SNR at 10 μm can be compared with the theoretical prediction of IR emission of shock-heated dust.

## 1. The Role of Dust in Supernova Remnants

Several theoreticians have investigated the behaviour of dust grains in the surroundings of a supernova explosion. It has been suggested by the computations (Silk and Burke, 1974, *Astrophysical Journal* **190,** 11) that thermal energy from the gas heated by the passage of the SN blast wave should be deposited in the dust grains by ion-grain and electron-grain collisions and subsequently radiated by the dust in the infrared. The efficiency of this cooling mechanism depends mainly on the interstellar medium pre-shock density and the shock velocity. Other important parameters are the assumed composition and size distribution of the grains and the rate of collisional heating and destruction for the grains in a hot plasma.

The more recent computations have dealt with a variety of physical cases. Shull (1980, *Ap. J.* **237,** 769) and Wheeler et al. (1980, *Ap. J.* **237,** 781) studied the emission of dust for the case of a SN exploding in the vicinity of a dense molecular cloud. In this case the main heating mechanism for the grains is absorption of UV and X-ray photons from the hot interior of the SNR, and the larger fraction of the infrared emission comes from the grains exterior to the shock. According to the theoretical computations, this type of remnants could be discovered in a survey of nearby galaxies at infrared and X-ray wavelengths but it is unlikely that it can be detected in the optical because of the heavy extinction in the dense material which surrounds the SN.

Draine (1981, *Ap. J.* **245,** 880) and Dwek (1981, *Ap. J.* **247,** 614) concentrated on the infrared fluxes expected from the dust heated by collisions in the hot interior of a SNR. This dust, originally associated with the interstellar gas, is only partially destroyed by the passage of the shock wave. Dwek and Werner (1981, *Ap. J.* **248,** 138) considered the emission from grains formed in the SN itself, which are to be found in the fast moving ejecta observed in the remnant or in the "evaporated" gas which surround them.

However detailed the calculations, there is as yet no direct observational evidence for the presence of grains in a SNR. For this reason, any observational results, being it a detection or a significant upper limit, is useful to understand the fate of dust in a SN vicinity. So far a systematic search for infrared emission (80–350 μm) has been made only in three young galactic SNR (Wright et al., 1980, *Ap. J.* **240,** L157).

## Preliminary Results for the 10 μm Emission from SNR in the LMC

Systematic observations of three remnants in the LMC were carried on one night last November at 10 and 12 μm, using the ESO bolometer attached to the 3.6-m telescope with a diaphragm of 7.5 arcsec diameter (see the article by Moorwood in this issue for details on the instrument).

The choice of our targets in the Large Magellanic Clouds has various motivations. For a given diaphragm, the fraction of a remnant surface seen at the distance of the LMC is much larger than for a galactic case thus making a systematic exploration much easier. On the other hand, if the dust is distributed

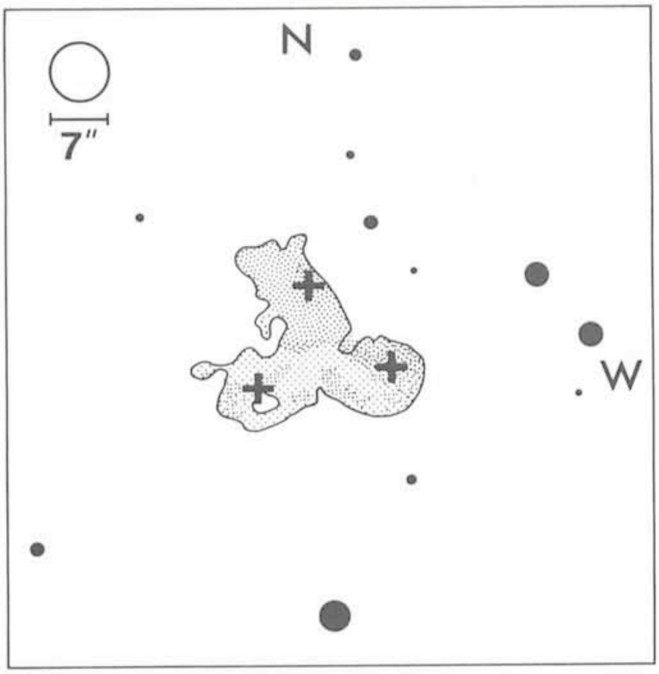

Fig. 1: *The positions of the 10 and 12 μm observations in the supernova remnant N63A and the adjacent H II region are indicated with crosses on this sketch from an Hα photograph by B. Lasker. The circle shows the size of the observing diaphragm. The probable detection was obtained in the south-east knot of the SNR.*

homogeneously the surface brightness is distance-independent. Finally, the specific properties of the three LMC remnants, N49, N63A and N132D, appear more favourable to the infrared emission than those of most galactic remnants in the southern hemisphere. They are the three brightest X-ray SNR in the LMC and among the brightest X-ray sources on an absolute scale in that galaxy. They have been observed with the Einstein Observatory High Resolution Imaging instrument (HRI) and the Solid State Spectrometer (SSS). When these results will become available we will know both the distribution and temperature of the hot plasma. As for the optical observations, it was already known from the work of, e.g., Dopita (1979, *Ap. J. Suppl.* **40,** 455) that the expansion velocity of the optical filaments is between 100 and 200 km/sec. In N132D, fast moving ($v \sim 4,000$ km/sec) knots of emitted materials are also observed. It has been suggested that some of these condensates represent processed material from the supernova explosion, where dust formation would be enhanced.

We observed three positions in N132D and N63A and two positions in N49. At one position in N63A (see Fig. 1) a flux of 130 mJy was measured at a 2.6 $\sigma$ level. At all other positions no detection was obtained at a 2 $\sigma$ level (50–80 mJy).

Since the properties of the dust are not defined univocally, we need to know with reasonable accuracy at least the temperature and density of the gas which heats it, to interpret the results. A detailed comparison of theory and IR observations must then wait for the publication of the Einstein Observatory results. However, by using the preliminary estimates which are available and, e.g., the theoretical formulation by Dwek and Werner (1981, *Ap. J.* **248,** 138) it is already possible to estimate the significance of our data. By assuming $\log T = 6.8$ and $n_e = 5$ for the hot gas we derive a grain temperature between 80 and 300 °K depending on the type and size of the grains. At the distance of the LMC, 130 mJy then imply 6.5 $M_\odot$ of dust in the first case, $6 \times 10^{-3}$ $M_\odot$ in the second. The first appears a much too large value to be acceptable.

The upper limits are also significant. For the higher grain temperature, 50 mJy imply a mass of dust of less than $2 \times 10^{-3}$ $M_\odot$, and a gas to dust ratio larger than $10^3$.

We stress again that these values are only indicative and an estimate of the total mass of dust and of its properties is premature. An additional uncertainty is in the geometrical correction to apply to a partial observation to get the integrated flux. It was pointed out in the preliminary discussion of Long, Helfand and Grabelsky (1981, *Ap. J.* **248,** 925) that the X-ray diameters of the LMC supernova remnants are significantly larger than the optical ones. If heated dust is present whereever hot gas is observed, the total infrared flux may be larger than expected.

From the point of view of the infrared observations, we hope in the near future to confirm the detection at 10 μm and extend the survey to the regions which do not emit optically but are visible in the X-ray maps. Under optimum observing conditions it should be possible to lower the $\sigma$ level by at least a factor of two and thus placing even more stringent limits on the dust content. It would be also quite useful to complement these results with observations at longer wavelengths with a future space-operated facility to detect or rule out the presence of a significant amount of dust at lower temperature.

If the dust behaves like the theoreticians think it should, the infrared observations of SNR seem indeed a useful way to investigate its presence and its properties.

# A Long Period Eclipsing Binary Project – Five Years of Observations at ESO

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The star HD 161387 first caught our eyes when we were reading an article on ζ Aurigae stars by K. O. Wright in *Vistas in Astronomy* No. 12. This was some 8 or 9 years ago.

ζ Aurigae stars are eclipsing binaries formed by a cool supergiant K star and a very much smaller and hotter main-sequence (more or less normal) B star. Out of eclipse the B star dominates the blue spectral region, but a pure K-type spectrum is found in eclipse. The drastic spectral changes for HD 161387 can be seen in Fig 1c and 1d. Periods for these binaries are in the range of 2 to 10 years. The general benefit of ζ Aurigae star studies is the possibility of direct determination of physical parameters of the components such as masses and radii. In practice, what one does observe is the change in radial velocity of the stars as they orbit around their common centre of gravity and the change in magnitude as the light from the B star is eclipsed by the K supergiant. There is also the possibility of studying the structure of the atmosphere of a K supergiant manifested by spectral changes occurring as the point light of the B star shines through the outer parts of the K star close to the total eclipse. Besides ζ Aurigae itself only the stars 31 and 32 Cygni have been studied in greater detail.

Looking through the literature we found that not very much