Figure 2: *Loading of the NTT boxes onto the ship in Genova harbour, 29 April 1988. In the front of the picture the box containing the base of the fork is visible. This box weighs about 44 tons.*

Figure 3: *The rotating building under construction in April 1988.*

Speckle Masking Observations of the Central Object in NGC 3603, Eta Carinae, and the Seyfert Galaxies NGC 7469 and NGC 1068

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Introduction

Speckle masking bispectrum processing yields diffraction-limited images in spite of image degradation by the atmosphere and by telescope aberrations. For example, with the ESO 3.6-m telescope a resolution of 0."028 can be obtained at $\lambda \sim 400$ nm. The limiting magnitude is $\sim 18^m$.

In speckle masking the same speckle raw data (speckle interferograms) are evaluated as in speckle interferometry. Speckle interferograms are short-exposure images recorded with an exposure time of ~ 10 to 50 msec. Speckle masking consists of the following processing steps (Weigelt, 1977; Weigelt and Wirnitzer, 1983; Lohmann, Weigelt and Wirnitzer, 1983):

(a) calculation of the average bispectrum of all speckle interferograms,
(b) compensation of the photon bias in the average bispectrum,
(c) compensation of the speckle masking transfer function,
(d) derivation of modulus and phase of the object Fourier transform from the object bispectrum.

We will show applications of speckle masking to various types of objects. The speckle raw data were recorded with the 2.2-m ESO/MPG telescope, the Danish 1.5-m telescope, and the 2.2-m Calar Alto telescope.

Central Object in the Giant H II Region NGC 3603

NGC 3603 is one of the strongest H II regions in our galaxy. The central object in NGC 3603 is the star-like object HD 97950 AB. In various papers it has been discussed that this object may be of the same nature as R 136a in the 30 Doradus nebula. Figure 1 is the first diffraction-limited image which shows that the central object in NGC 3603 consists of six stars. In this experiment CLEAN was applied to the speckle masking reconstruction. The stars have magnitudes in the range of 12 to 14. The separation of the closest pair is ~ 0.09". The image was reconstructed from 300 speckle interferograms recorded with the 2.2-m ESO/MPG telescope (filter RG 610). An image of the four brightest stars was reconstructed by Hofmann and Weigelt (1986).

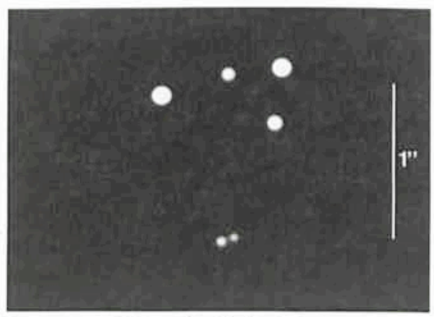
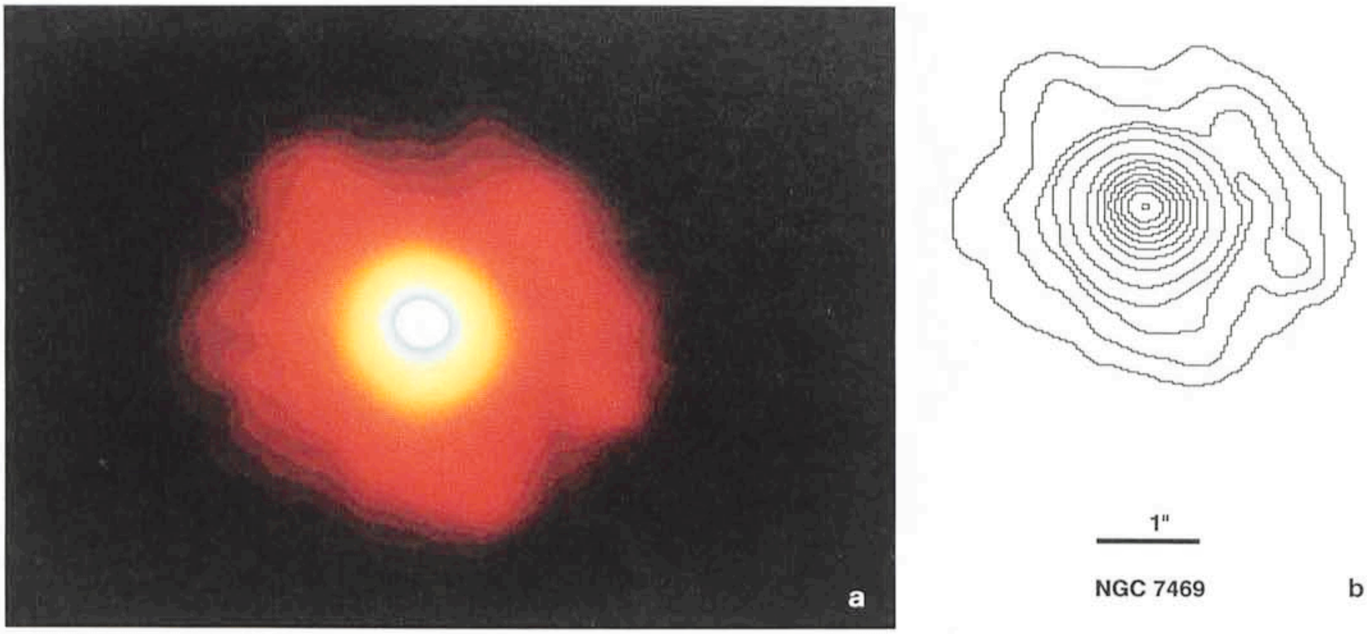


Figure 1: *Diffraction-limited image of the central object in the giant HII region NGC 3603 reconstructed by speckle masking (filter RG 610; North is at the top and East to the left).*

Eta Carinae

η Carinae is one of the most peculiar objects in our galaxy. It underwent

Figure 2: *Diffraction-limited image of η Carinae ABCD (filter RG 830; North is at the top and East to the left).*



Figures 3a and b: *High-resolution image of NGC 7469 reconstructed by speckle masking (filter: $\lambda_c \sim 610$ nm/$\Delta\lambda \sim 118$ nm; North is at the top and East to the left; isophotes: 1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.15, 0.13, 0.11, 0.09).*

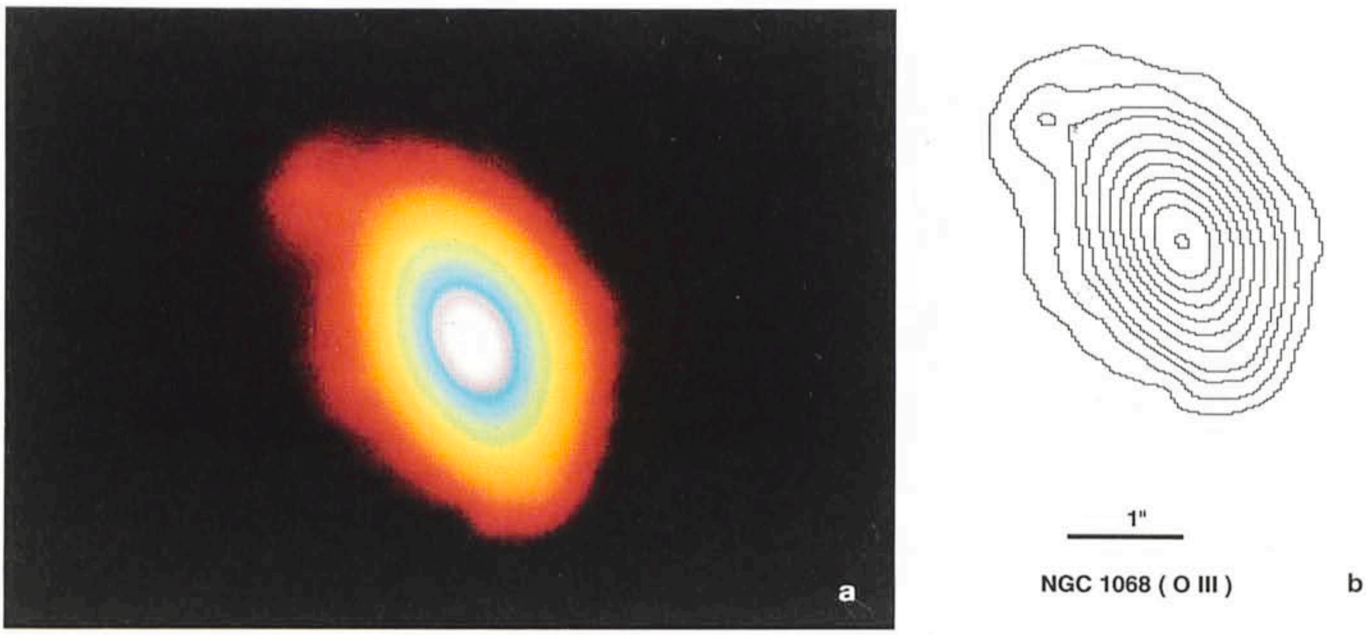
dramatic brightness changes during the last 300 years: 4^m in 1667, -1^m during the outburst in 1843, present magnitude $\sim 6^m$. It is surrounded by the homunculus nebula, which consists of material blown from the star during its strong eruption from 1830 to 1860. η Carinae is one of the most extreme IR sources in the sky at $\lambda \sim 20$ μm. Its mass is probably ~ 100 solar masses. Figure 2 is the first diffraction-limited image of η Carinae at optical wavelengths. The image shows that η Carinae consists of a dominant bright star and three faint, star-like objects at separations 0.11″, 0.18″, and 0.21″. The three faint objects are ~ 12 times fainter than the dominant star. The image of η Carinae was reconstructed from 300 speckle interferograms recorded with the 2.2-m ESO/MPG telescope at $\lambda_c \sim 850$ nm (filter RG 830). More details are described in a paper submitted to *Astron. Astrophys.* (Hofmann and Weigelt, 1988).

Seyfert I Galaxy NGC 7469

Figure 3 shows a speckle masking observation of the Seyfert I galaxy NGC 7469 (filter $\lambda_c \sim 610$ nm/ $\Delta\lambda \sim 118$ nm). The image was reconstructed from 2,900 speckle interferograms recorded with the 2.2-m telescope at Calar Alto observatory in Spain. The image shows five clouds surrounding the central object. In the next few weeks we will improve the image by reducing additional 15,000 speckle interferograms.

Seyfert II Galaxy NGC 1068

Figure 4 shows an image of the Seyfert II galaxy NGC 1068 reconstructed from 2,400 speckle interferograms by



Figures 4a and b: *High-resolution image of NGC 1068 reconstructed by speckle masking (filter: $\lambda_c \sim 501$ nm/$\Delta\lambda \sim 25$ nm; North is at the top and East to the left; isophotes: 1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.25, 0,20, 0.15)* speckle masking. The speckle interferograms were recorded with the Danish 1.5-m telescope and an OIII filter ($\lambda_c \sim 501$ nm/$\Delta\lambda \sim 25$ nm). There is an interesting similarity between the OIII image and radio images.

References

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SN 1987 A (continued)

The study of SN 1987 A continues to occupy many astronomers at the major southern observatories. Some of the programmes have now settled down to routine, while others exploit new techniques, all in order to harvest as much information as possible from this rare event.

Since the last summary of recent developments in this journal (*The Messenger* **51,** 9), new and exciting observations at the European Southern Observatory have become available, which probe the interstellar space at different distances from the supernova by means of very different techniques.

On the smallest angular scale, *speckle masking observations* in the visual and near infrared spectral regions have been made in December 1987 by a group from the Erlangen-Nürnberg University, working at the ESO/MPG 2.2-m telescope. With this powerful method they are able to establish upper limits for the size of the expanding supernova shell, which was ejected at the time of the explosion last February. Their value is around 0.023 arcsec. They will report their results for the supernova in a future issue of the *Messenger.*

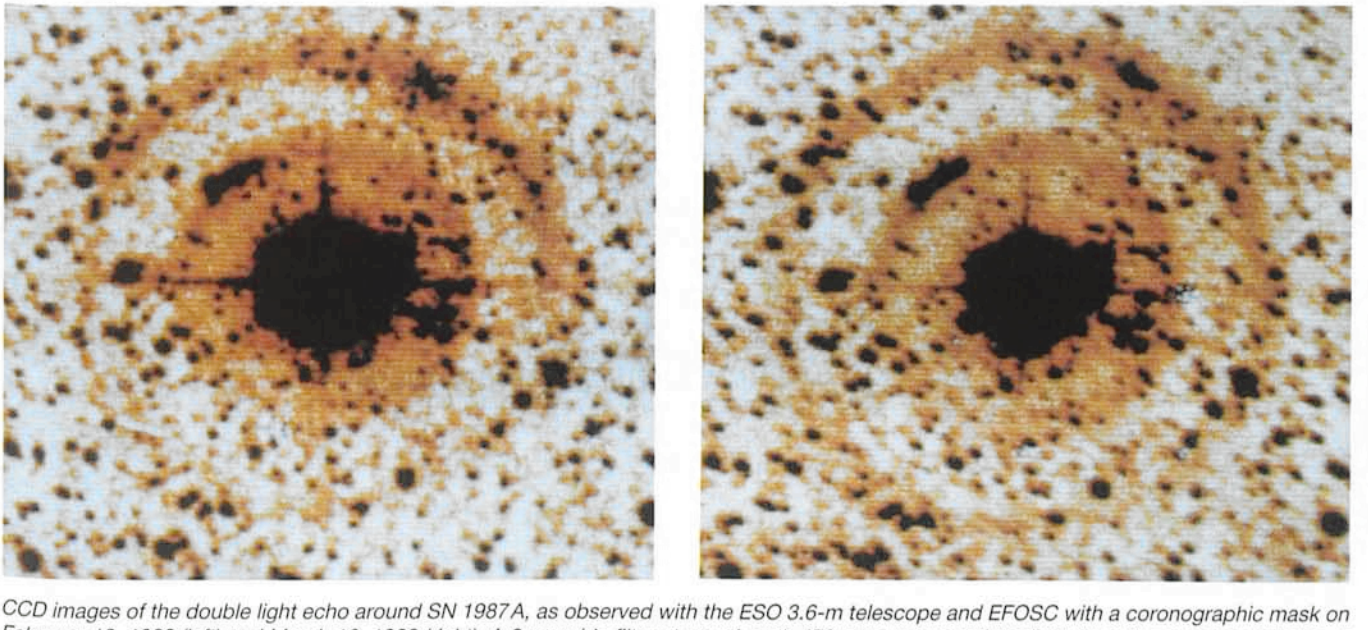
The summary about *infrared speckle observations* by Chalabaev and co-authors with the ESO 3.6-m telescope (*The Messenger* **50,** 21) has now been followed up by a comprehensive paper, which was submitted to the journal *Nature* in April 1988. The detection of an infrared light echo is confirmed with a radius of 0.350 arcsec on August 6, 1987.

This infrared echo is thought to result from the thermal re-radiation of the initial light flash by dust grains formed during a previous phase, when the exploding star Sanduleak −69°202 had been a red supergiant with a strong mass loss. From the date of the first detected infrared light echo, the size of the dust-free shell can be estimated. Knowing also the outward velocity of the material, it would appear that the red supergiant mass loss phase ended only a few thousand years before the explosion.

This is also a result of *high-resolution spectral observations* by Wampler and Richichi, reported in this *Messenger* issue. This paper shows for the first time an image of the shell of material from the mass loss phase, measuring about 2 arcsec across. The observations were made in 1988 with the CES and the 1.4-m CAT telescope. A more detailed report has now been submitted to the journal *Astronomy and Astrophysics.*

On a still larger scale, a *double, visible light echo* has recently been detected. Contrary to the infrared echo referred to above, this echo arises from the reflection of the bright supernova light in interstellar clouds much farther away from the exploded star.

Astronomers had been searching for this phenomenon since last year. A detection on March 3, 1988, was announced by A. Crotts from McDonald Observatory, Texas, USA. However, by inspection of earlier images made at the European Southern Observatory, it was seen on CCD frames made on January 25 by H. Pedersen with the Danish 1.5-m telescope and also on February 13, by M. Rosa with the ESO 3.6-m telescope. Later, it was also found that the outer echo can be seen as early as in August 1987, on EFOSC CCD frames obtained by S. D'Odorico, and also on a dozen Schmidt photographic plates after November 1987. Further observations were made in mid-March, with the



CCD images of the double light echo around SN 1987 A, as observed with the ESO 3.6-m telescope and EFOSC with a coronographic mask on February 13, 1988 (left) and March 16, 1988 (right). A 6 nm wide filter at wavelength 470 nm suppressed the light from the emission nebulae in this region. Observers: M. Rosa, Chr. Gouiffes and M. T. Ruiz. A careful comparison shows the expansion, at present about 3 arcsec/month.