MAPPIT: OPTICAL INTERFEROMETRY WITH NON-REDUNDANT MASKS*

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1. The Instrument

MAPPIT (Masked APerture-Plane Interference Telescope) is an optical interferometer mounted at the coudé focus of the 3.9 m Anglo-Australian Telescope. The instrument, shown schematically in Fig. 1, uses a pupil mask with five apertures of diameter $\lesssim r_0$. The apertures are arranged in a linear non-redundant array, with the spacings chosen to optimize the spatial frequency coverage (R. G. Marson, these Proceedings).

The interferometer includes a prism and cylindrical optics in a novel configuration which allows us to record dispersed fringes over a wide bandwidth. More details of the instrument can be found in Bedding (1992) and Bedding *et al.* (1992).

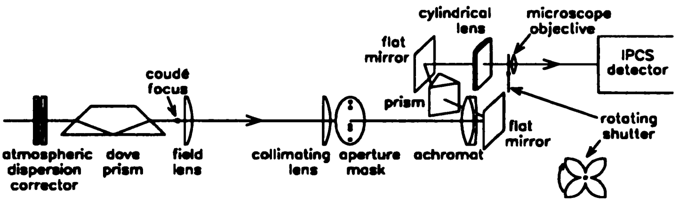

Fig. 1. Schematic view of the main components of MAPPIT (not to scale).

2. Results

In Fig. 2 we show visibility amplitudes from two late-type stars. Our diameter for α Sco agrees well with a recent lunar occultation measurement by Richichi and Lisi (1990). To our knowledge, the M5 III giant β Gru has not been resolved before.

Previously, MAPPIT has produced images of the binary stars η Oph (Robertson *et al.* 1991) and δ Sco (Marson *et al.* 1992; Bedding 1993). Fig. 3 shows bispectrum data from another double star (ι^1 Lib), displayed in a new way. This method of displaying the bispectrum, explained in the figure caption, allows one to compare the observations directly with a model of the source.

THE DOUBLE STAR σ SGR

Using the Narrabri intensity interferometer, Hanbury Brown *et al.* (1974) discovered this star to be a binary with components of roughly equal brightness

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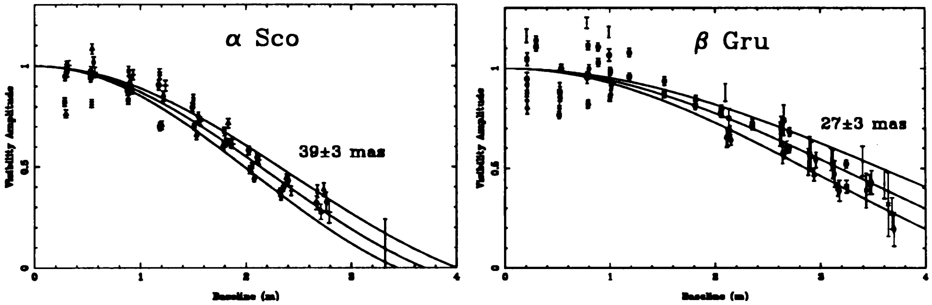

Fig. 2. Calibrated visibility amplitudes for two resolved stars, fitted by uniform disks. The observations were made in wavelength bands 565–582 nm (α Sco) and 565–618 nm (β Gru).

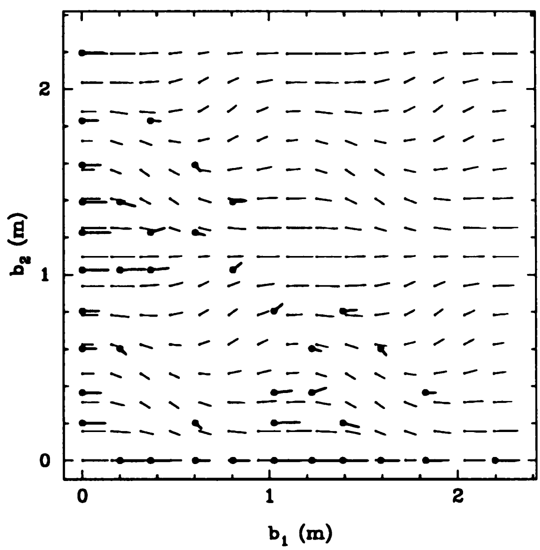

Fig. 3. Bispectrum phasors (in bold) from a single observation of the double star ι^1 Lib. For comparison, we also show bispectra phasors calculated from a model (a double with separation 108 mas and $\Delta m = 1.5$). The plot is in spatial-frequency space, with the axes showing baselines (in metres) along the one-dimensional mask array. The two axes of the plot represent the lengths of the two shortest sides of a closure triangle. Each phasor in the figure shows the complex bispectrum calculated from such a triangle of baselines. The argument of each phasor is the closure phase and the modulus is the product of the three relevant visibility amplitudes.

($\Delta m = 0.6 \pm 0.5$). Presumably on the basis of this result, σ Sgr is recorded in the *Bright Star Catalogue* (Hoffleit 1982) with a note: 'Interferometry measures indicate multiple star.' The Hanbury Brown *et al.* measurement gave no information about the geometry of the components. Although the star is bright ($V = 2.8$), we can find no mention in the literature of other observations.

We observed σ Sgr with MAPPIT in July 1991. Visibilities on the longest baselines were substantially reduced at some position angles, consistent with the object being a barely-resolved double. Because the system is only just resolved by our observations, it is difficult to determine the magnitude difference accurately. When we assume $\Delta m = 0$ and fit to the visibility amplitudes, we obtain a position angle $(22 \pm 10)°$ and separation (11.5 ± 2) mas. This model is shown by the solid curves in Fig. 4, in which the data have been projected along a position angle of 22°. However, non-zero values of Δm fit the observations equally well. For example, the dashed

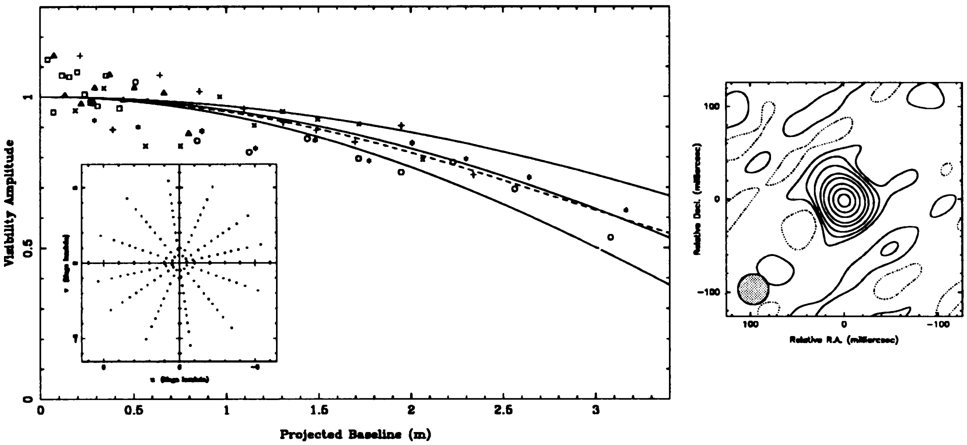

Fig. 4. Calibrated visibility amplitudes of σ Sgr. The inset shows the (u, v) coverage. In the reconstructed image (right), note that north is down and east is to the right. The model fitting and image reconstruction were done using the Caltech VLBI software.

curve shows the visibilities expected with $\Delta m = 1.0$ and separation 13.5 mas.

If the double is unequal, visibility amplitudes alone cannot resolve the 180° ambiguity (i.e., establish the parity of the binary). We therefore repeated the modelling process with the closure phases included. The best fit to an unequal double was for $\Delta m = 0.2$ and position angle 202° (i.e., with fainter component to the south). This orientation is visible in the asymmetry in the image shown in Fig. 4, which was made using conventional hybrid mapping techniques. However, it must be noted that the signal-to-noise ratio in the closure phases is not high enough to determine Δm accurately or to establish the parity with certainty.

Finally, we note that the aperture mask has allowed us to achieve very good angular resolution. In this regard, using a fully-filled aperture would have two disadvantages: (i) it gives diminished weighting to long baselines, and (ii) it is more difficult to calibrate the visibility amplitudes because of atmospheric noise caused by the redundancy of the pupil.

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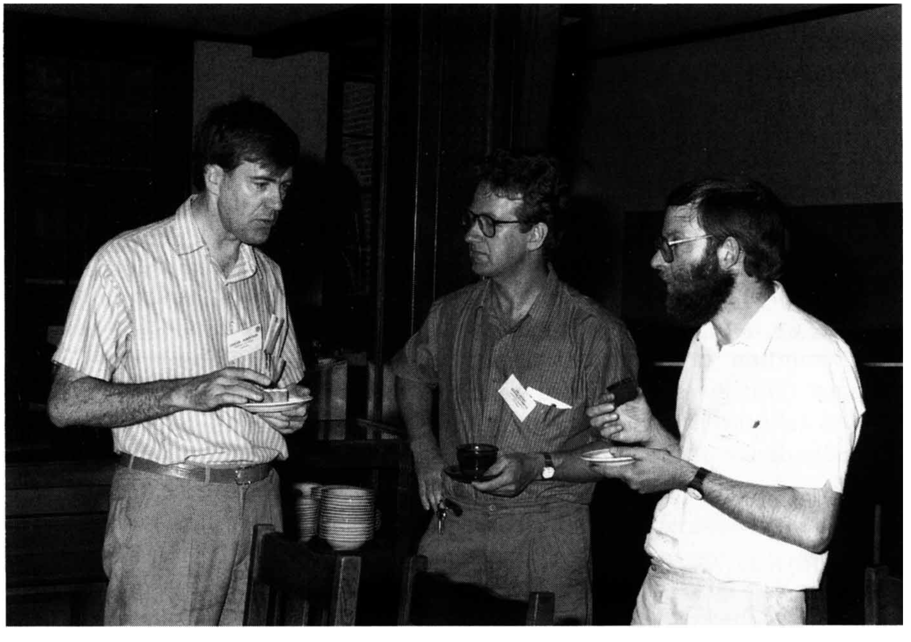
Discussion:

Burke:
You mentioned the use of a long thin slit as a useful partially redundant pupil. How would a thin annular pupil compare with this?
Response by Haniff:
In the photon limited regime this is a relatively poor choice. In this regime the S/N of the bispectrum scales as Redundancy $\times$ (pupil area)$^{-\frac{3}{2}}$. Since a thin annulus has low redundancy and a large area, this gives relatively poor S/N for bispectrum measurements.



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