AMPLITUDE INTERFEROMETRY AT C.E.R.G.A.

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INTRODUCTION

The 12 to 20 metre baseline interferometer at C.E.R.G.A. built by A. Labeyrie has now been operational for two years. The purpose of this instrument was initially to be a prototype showing the feasibility of long baseline coherent arrays and for testing the techniques needed for them. Yet, pending completion of large interferometers, this small 2 x 26 cm instrument has proven able to yield astrophysical data: a dozen stars up to third magnitude have been observed with a 3×10^{-3} arc second resolution on diameters and a 5×10^{-4} arc second accuracy for binary separation measurements in the case of α Aur.

What has been observed both from the technological and the astrophysical point of view will be discussed.

1. INSTRUMENT FEATURES

Stability is far more important here than for classical telescopes, as the permissible vibrations of the optical paths should not exceed a few microns and a few Hertz. With 300 kg mounts for each telescope consisting of horizontal steel yokes and concrete bases rolling on tracks, the observed total amplitude (atmosphere plus mechanics) is less than .2 microns at 50 Hertz and less than 3 microns at 1 Hertz.

Guiding would be perfect if it kept both star images constantly superposed, but the inertia of the telescope does not allow a fast enough response for correction of atmospheric agitation. Such a problem will not occur with larger aperture telescopes which display a more stable speckle pattern.

Our present guiding system uses feedback from the star images on a T.V. monitor to the telescopes controls. With its 1 arc second accuracy, good superposition occurs 50% of the time.

Fringe tracking, necessary because of the horizontal N-S baseline (not parallel to the earth's rotation axis) is done by moving all the detecting

https://doi.org/10.1017/S0252921100118688 Published online by Cambridge University Press

devices along tracks during observation with microprocessor control. A fairly good precision can be achieved but a preprogrammed motion cannot correct random oscillations caused by the atmosphere, microseisms and mechanical problems as thermal expansion, so manual corrections have to be made.

A real improvement will be computerised feedback from the stellar images. One can use a photon counting TV camera with an on-line computer looking for dephasings between fringe patterns at two neighbouring wavelengths.

2. CONTRAST MEASUREMENT

The precision of the measurement of contrast is directly related to the precision of the astrophysical data. We use a photon counting television camera and a video tape recorder for storing series of 20 millisecond exposures on fringe images. Until now we compared contrasts visually on a TV screen, using calibrated fringe sequences for reference. Those sequences were generated with Vega (α Lyr) at 12 metres baseline, which yields a contrast of 0.8 ± 0.1. Inserting polarisers or Dove prisms into the beams from the telescopes and rotating one of these would lower the contrast by a known value and generate reference contrasts between 0.8 and 0.1. This method has a 25% precision.

This is now being improved: the contrast measuring device presently involves the photon counting camera interfaced to a minicomputer generating two values of the Fourier transform's modulus for each frame: one at zero frequency and one at the fringes' spatial frequency.

Contrast is given by:

$$C = 2 \frac{|\tilde{g}(\omega_F)|^2}{|\tilde{g}(o)|^2}$$

where ω_F is the fringe frequency and

$\tilde{g}(\omega)$ means the Fourier transform of fringe pattern.

The contrast changes randomly from one frame to another, due to seeing and guiding inaccuracy, and averages will be seeing dependent. As what causes

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the changes always acts to decrease the contrast, the computer displays histograms of contrast and looks for a maximum.

Reference sequences will still be necessary because of the camera's non-linearity, and data will be derived from the orientation of the Dove prism which equalises maxima of reference and observed histograms.

This method will be used shortly and we expect a 5% precision.

3. ASTROPHYSICAL RESULTS

According to the present 25% relative precision on contrasts the accuracies for star diameters range from 10^{-3} to 2×10^{-3} arc seconds.

The case of the binary star α Aur is more favourable as it displays a faster spatial frequency dependent modulation in contrast. A dispersed image of channels shows maxima and minima of contrast and one can measure their wavelength with a 1% accuracy, deriving angular separations with the same precision.

Some results are presented in Tables I and II.

4. FUTURE OBSERVATIONS AND INTERFEROMETERS AT C.E.R.G.A.

The baseline tracks of the present instrument are about to be extended to 40 metres, and we expect a two-fold increase in resolution and accuracies.

Systematic observations of stars brighter than third magnitude, ranging from 20° to 65° north will be performed during the year.

Another interferometer is being built, involving 1.5 m aperture telescopes and possible extensions of baselines to 300 m. One of the two spherical concrete telescopes is presently being tested at C.E.R.G.A. and we expect the 2nd generation interferometer to be operational in two years.

TABLE I Star diameters

Name	Diameter in arc sec
α Lyr	$3.9 \pm 1 \times 10^{-3}$
α Aur A	5.2 ± 1
α Aur B	4.0 ± 1
ε Uma	3.1 ± 1*
α Cyg	4.5 ± 1
α Gem A	< 2.5
η Uma	< 2.5
γ Cyg	< 2.5

* possibly double, in which case the datum would be over-valued

TABLE II Some separations and orientations of α Aur *

Date	Separation	Orientation
1977.125	$38''.5 \times 10^{-3}$	116.8°
1977.168	56.0	58.4°
1977.207	57.5	31.8°
1977.896	55.0	39.4°

* Accuracy is $+5 \times 10^{-4}$ arc seconds for N-S direction and $+4 \times 10^{-3}$ arc seconds for E-W direction

https://doi.org/10.1017/S0252921100118688 Published online by Cambridge University Press

REFERENCES

1) J.A. Anderson, Ap. J. 51, 263, 1920

2) A. Blazit, D. Bonneau, L. Koechlin, A. Labeyrie, Ap. J. (Lett.) 214, 279, 1977

3) L. Koechlin, "Optical Telescopes of the Future" (ESO, Geneva), eds F. Pacini, W. Richter and R.N. Wilson, p.475, 1977

4) A. Labeyrie, Ap. J. (Lett.) 196, L71, 1975

5) A. Labeyrie, "Optical Telescopes of the Future" (ESO Geneva), eds. F. Pacini, W. Richter and R.N. Wilson, p.375, 1977

6) R. Hanbury Brown, J. Davis and L.R. Allen, Mon. Not. R. astr. Soc., 167, 121, 1974.

7) A.A. Michelson, Ap. J 51, 257, 1920

DISCUSSION

M. Shao: Do you intend to put the camera behind the prism?

L. Koechlin: Yes. This will also use an anamorphic lens in order to fit the spectrum into the field of the TV camera.

D. Gezari: What type of detector will you use for the large interferometer you and Labeyrie are building and what will the magnitude limit be?

L. Koechlin: We will probably use the same type of photon counting camera interfaced to a computer. The limiting magnitude should be at least 8 with an accuracy of 5% in the fringe contrast measurement.

https://doi.org/10.1017/S0252921100118688 Published online by Cambridge University Press