

ERIS 2007

BONN

MULTIPLYING  
INTERFEROMETER



"CORRELATOR"

R. W. PORCAS

(monochromatic)

## MULTIPLYING INTERFEROMETER

### PATH COMPENSATION

$$\rightarrow V_A(t) \cdot V_B(t+\tau_0) = S_c = S$$

### PHASE ERROR $\phi$

$$V_A(t) \cdot V_B(t+\tau_0) = S_c = S \cos \phi$$

sine + cosine  $\times$   $= S e^{i\phi}$

### OFFSET SOURCE AT $\Delta\theta$

$$V_A(t) \cdot V_B(t+\tau_0) = S e^{i[2\pi q \Delta\theta]}$$

### MANY OFFSET SOURCES AT $\Delta\theta_k$

$$V_A(t) \cdot V_B(t+\tau_0) = \sum S_k e^{i2\pi q \Delta\theta}$$

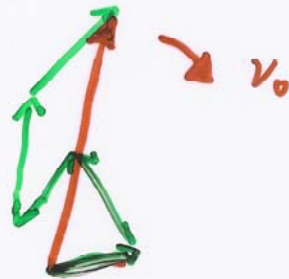
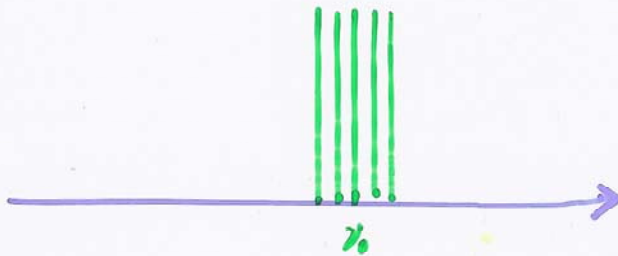
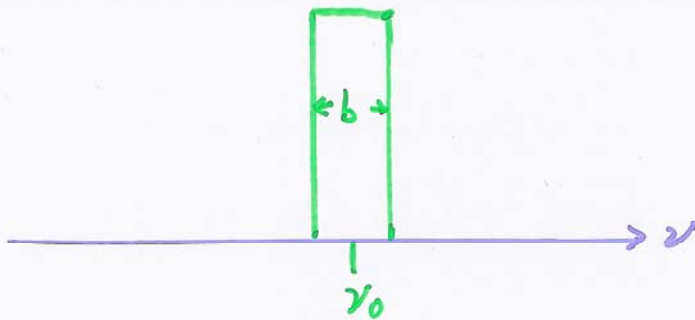
### DISTRIBUTION OF BRIGHTNESS $b(\theta)$

$$V_A(t) \cdot V_B(t+\tau_0) = \int b(\theta) e^{i2\pi q \theta} \cdot d\theta$$

2D:  $\theta \rightarrow x, y$   $q \rightarrow u, v$

$$V_A(t) \cdot V_B(t+\tau_0) = \int b(x, y) e^{i2\pi(u x + v y)} dx dy$$

COHERENCE FOR BW =  $b$



AFTER TIME  $\frac{1}{b}$  THE RELATIVE ROTATION OF  $\nu_0$  PRODUCES NEW RESULTANT WITH ARBITRARY PHASE OFFSET

LARGE UNCOMPENSATED PATH

$$V_A(t) \cdot V_B(t + \tau_0 + \tau) = 0$$

$$\tau > \frac{1}{b}$$

VLB/ UNCERTAIN PATH DIFFERENCE

"MULTI-LAG" MULTIPLICATION

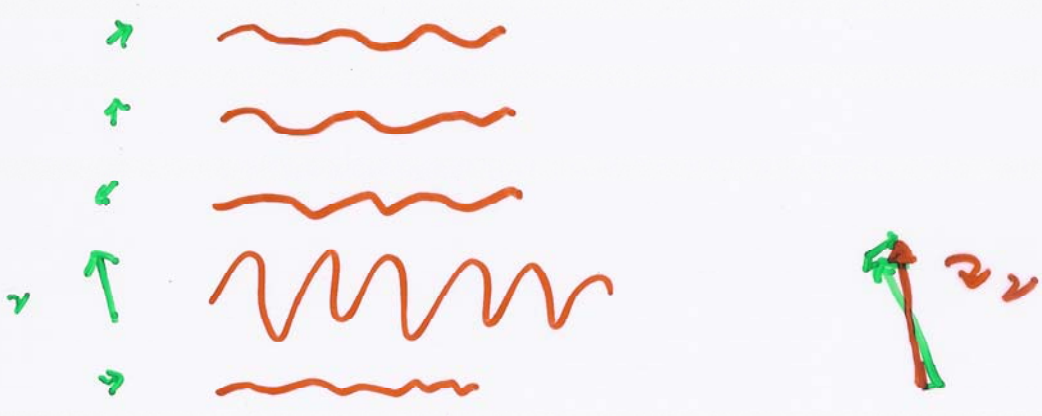
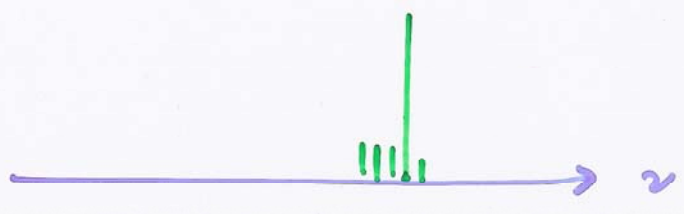
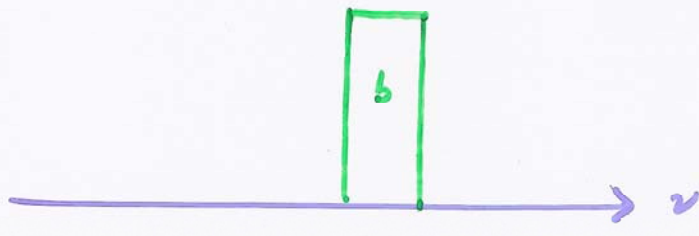
- ⋮
- $V_A(t) \cdot V_B(t + \tau_0 - 2\Delta\tau)$
- $V_A(t) \cdot V_B(t + \tau_0 - \Delta\tau)$
- $V_A(t) \cdot V_B(t + \tau_0)$
- $V_A(t) \cdot V_B(t + \tau_0 + \Delta\tau)$
- $V_A(t) \cdot V_B(t + \tau_0 + 2\Delta\tau)$
- ⋮

$$\langle V_A(t) \cdot V_B(t - \tau) \rangle$$

TIME DELAY CROSS CORRELATION FUNCTION

FRINGE SEARCH

FIND  $\tau$  WHICH MAXIMISES SIGNAL



PHASE IS "COHERENT" (PREDICTABLE)

FOR TIME  $> \frac{1}{b}$

CONTINUUM



$V_A(t) \cdot V_B(t-\tau)$

peak at  $\tau = \tau_0$

LINE



$V_A(t) \cdot V_B(t-\tau)$

Broader response

$V_A(t) \cdot V_B(t-\tau)$     FT     $S_c(\nu)$

# "SPECTRAL LINE MODE"

MULTIPLICATION



TIME-DELAY

CROSS CORRELATION FUNCTION

$$V_A(t) \cdot V_B(t + \tau_0)$$



$$V_A(t) \cdot V_B(t + \tau_0 + \tau)$$



visibility function



$$V_A \cdot V_B(\nu)$$

16 channels  
32  
64  
128

## WHY

- NEED TO LOCATE CORRECT DELAY COMPENSATION IN VCB |
- CAN IMAGE USING (e.g. 32) NARROW BAND CHANNELS FOR WIDER F.O.V.
- SPECTRAL LINE IMAGING

*Mina*

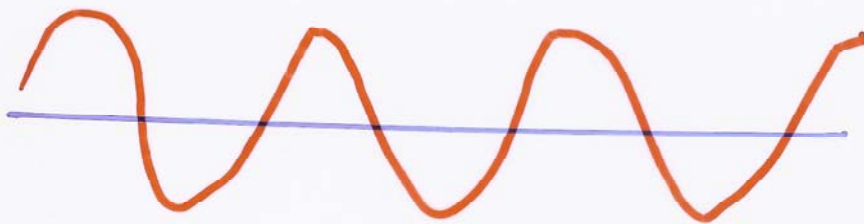
(1-bit) SAMPLING



$V_A(t) \cdot V_B(t)$



SAMPLE  $\frac{1}{2B} = 4$  points / cycle at  $v = \frac{b}{2}$



A 1 1 0 0 1 1 0 0 1 1 0 0 1

B 1 0 0 1 1 0 0 1 1 0 1 0

AxB 1 0 1 0 1 0 1 0 1 1 1 0 0

$\langle AxB \rangle = 0.5$

Excess if correlation between bit streams  
 deficit if anti - " " "



## VISIBILITY FUNCTION

→ CORRELATION COEFFICIENT

$\gamma = 1$  if perfect correlation

$\gamma = 0$  if no correlation

$\gamma \propto V_A V_B$

but is dimensionless

To convert  $\gamma \rightarrow S_C(I_y)$

must know the noise level in  $I_y$

SEFD

$$S_C = \gamma \sqrt{\text{SEFD}_A \cdot \text{SEFD}_B}$$