DARA 2017 Nairobi Unit1 Radioastronomy Workshop on Lecture 6

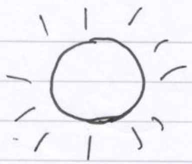
The Sun is observed with a two-element interferometer operating at a frequency of 600 MHz. The antennas can be physically moved apart. At what baseline length (in metres) will the amplitude of the fringe visibility first fall to zero?

A two element East-West interferometer has a baseline of 100 metres and is operated at a frequency of 300 MHz; the antennas have a diameter of 10 metres.

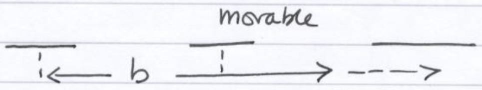
- What is the fringe period (separation) and angular frequency on the sky when the antennas are pointed at the zenith?
- About how many fringes will be seen inside the envelope set by the antenna beam?
- If a radio source is on the celestial equator (i.e. rotating across the sky at the same angular speed as the Earth) what will be rate at which it moves through one fringe period (answer cycles per sec). Note this is called the “fringe rate”.

Approximately what length of baseline (in metres) is needed to probe the central regions of an active galactic nucleus with a resolution of 0.1 milliarcsecond (hint: first turn this angle into radians) at an observing frequency of 10 GHz. Do you see any problem with your answer?

7.

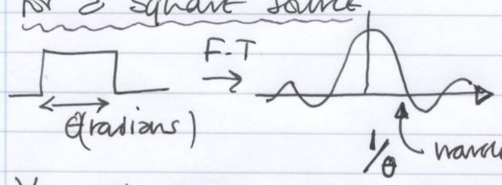


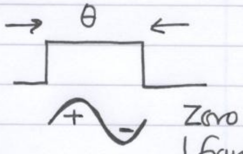
Solar diameter = $0^\circ.5$
(given earlier in course
or could find on web)



$\nu = 600$ MHz
$\lambda = 0.5$ m

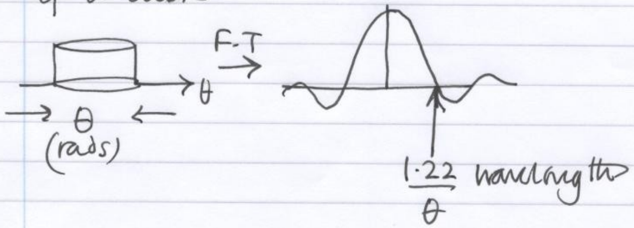
Sun is a circular source: F.T is $(J_1(x)/x)$ compared
with $(\sin x/x)$ for a square source
For a square source





Zero for
1 fringe
cycle across
source

You all know $1.22\lambda/d$ for resolution
of a disk



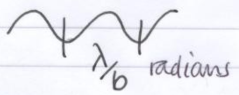
∴ 1st minimum at $\frac{1.22 \times 180}{0^\circ.5 \times \pi} = 139.8$ wavelengths

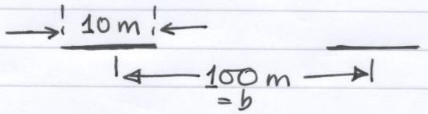
$= 139.8 \times 0.5 = \underline{69.9 \text{ metres}}$

We used to do ≈exactly this experiment in the JB
MSc course in the 1960s – 1970s!

Lecture 6 slide 27
Lecture 2 slide 2

4.





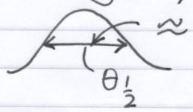
$\nu = 300$ MHz

$\rightarrow \lambda = 1$ m

Fringe period $= \frac{\lambda}{b} = \frac{1}{100}$ radian $= 0^\circ.573$

Angular frequency 100 cycles/radian

Antenna beam

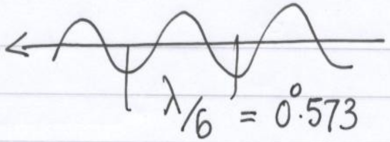


$\approx \lambda/d$ regardless of antenna design

$\therefore$ within $\theta_{\frac{1}{2}} = \frac{b}{d}$ fringes ie. ≈ 10

within whole beam $\approx$ 2x as many (estimate) ~ 20 fringes

radio source



Rotation rate of earth $= 15^\circ$/hour (360° in 24h)

$\therefore$ $= 1^\circ$/4mins

$\therefore$ $0^\circ.573$ in $0^\circ.573 \times 4$mins $= 2.29$mins

ie. $\boxed{\text{1 fringe per 137.5 seconds}}$

$\boxed{\text{or 7.272 milliHz}}$

7.

6\. Angular size of source = 0·1 milliarcsecond

$1 \text{ arcsec} = \frac{1}{60} \times \frac{1}{60} \times \frac{\pi}{180}$ radians $= 4{\cdot}85 \times 10^{-6}$

$\therefore$ 0·1 milliarcsec = $\underline{\underline{4{\cdot}85 \times 10^{-10}}}$ radians

$\lambda = 0{\cdot}03$ for $\nu = 10\,\text{GHz}$

To resolve need fringes of $\approx$ same angular period

$\therefore \frac{\lambda}{b} = 4{\cdot}85 \times 10^{-10} \rightarrow b = (4{\cdot}85 \times 10^{-10})^{-1} \times 0{\cdot}03$

$b = \underline{\underline{6{\cdot}18 \times 10^{7} \text{ metres}}}$

$b \approx 62{,}000$ km $= 10 \times R_{EARTH}$!! Need space radio telescope!