Universiteit van Amsterdam

ASTRON

Exploring polarization…

…and other matters

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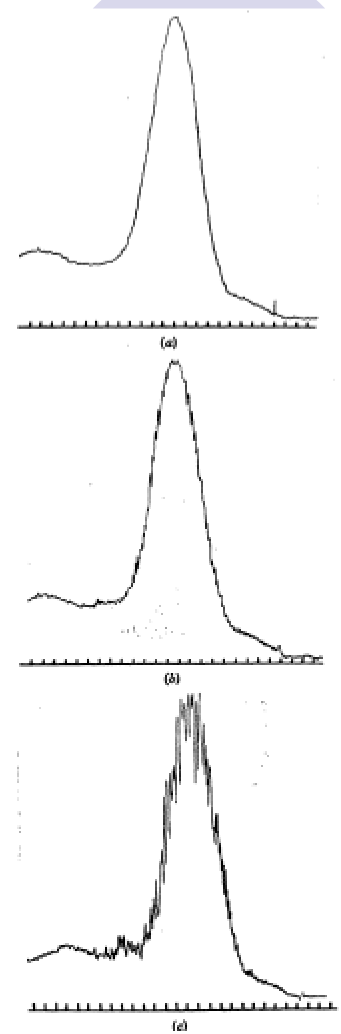
In 1948, some things were clear about radio sources

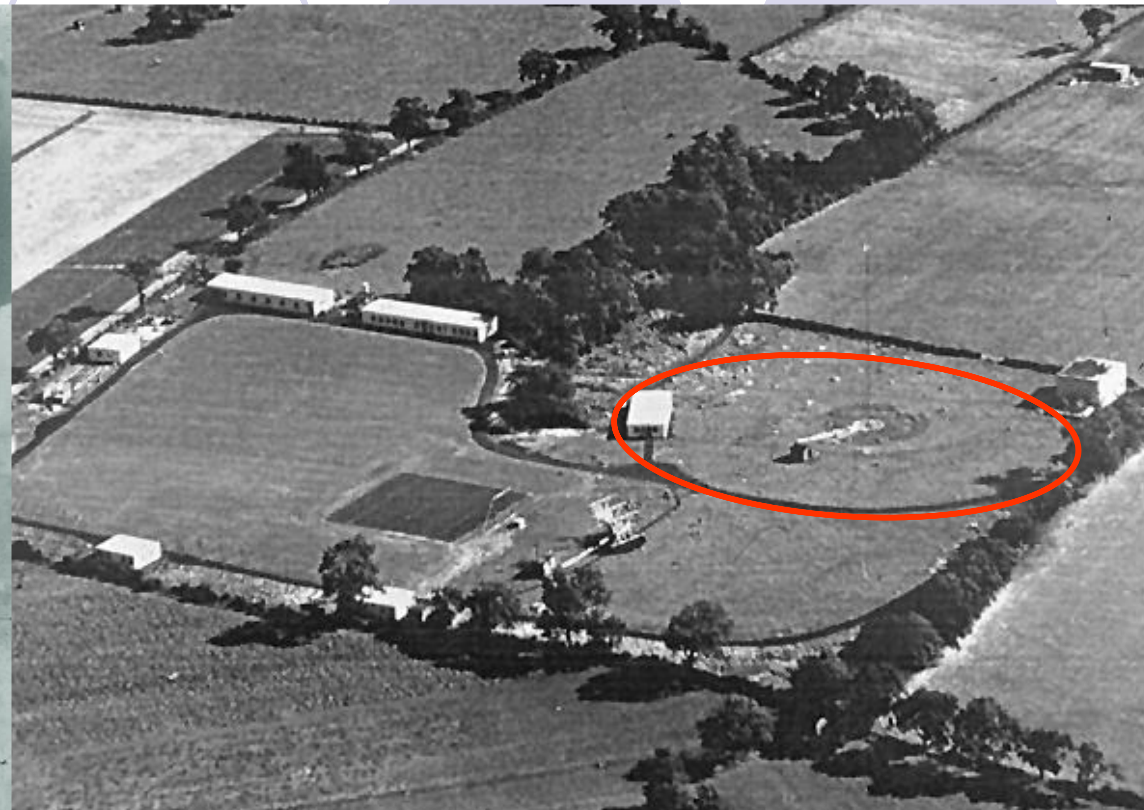
- The Galaxy and sun emit radio waves
- There are also compact sources (“radio stars”)
- The moon (and planets) were detectable as thermal emitters
- The emission mechanism for most sources was, however, unknown
- A few other sources were “identified” – with supernova remnants (Crab Nebula) and bright, nearby galaxies (Cen A)

Evidence for source compactness: ionospheric scintillation of Cyg A

- Discovered by Hey et al. (1946)
- Provided technique to increase angular resolution in radio band
- Observations by Hanbury Brown & Hazard (1951) shown here
- Observed with Jodrell Bank 218’ zenith transit paraboloid at 158.5 MHz
- Increasing scintillation (top to bottom) shown



The 218′ zenith transit parabolic dish at Jodrell Bank



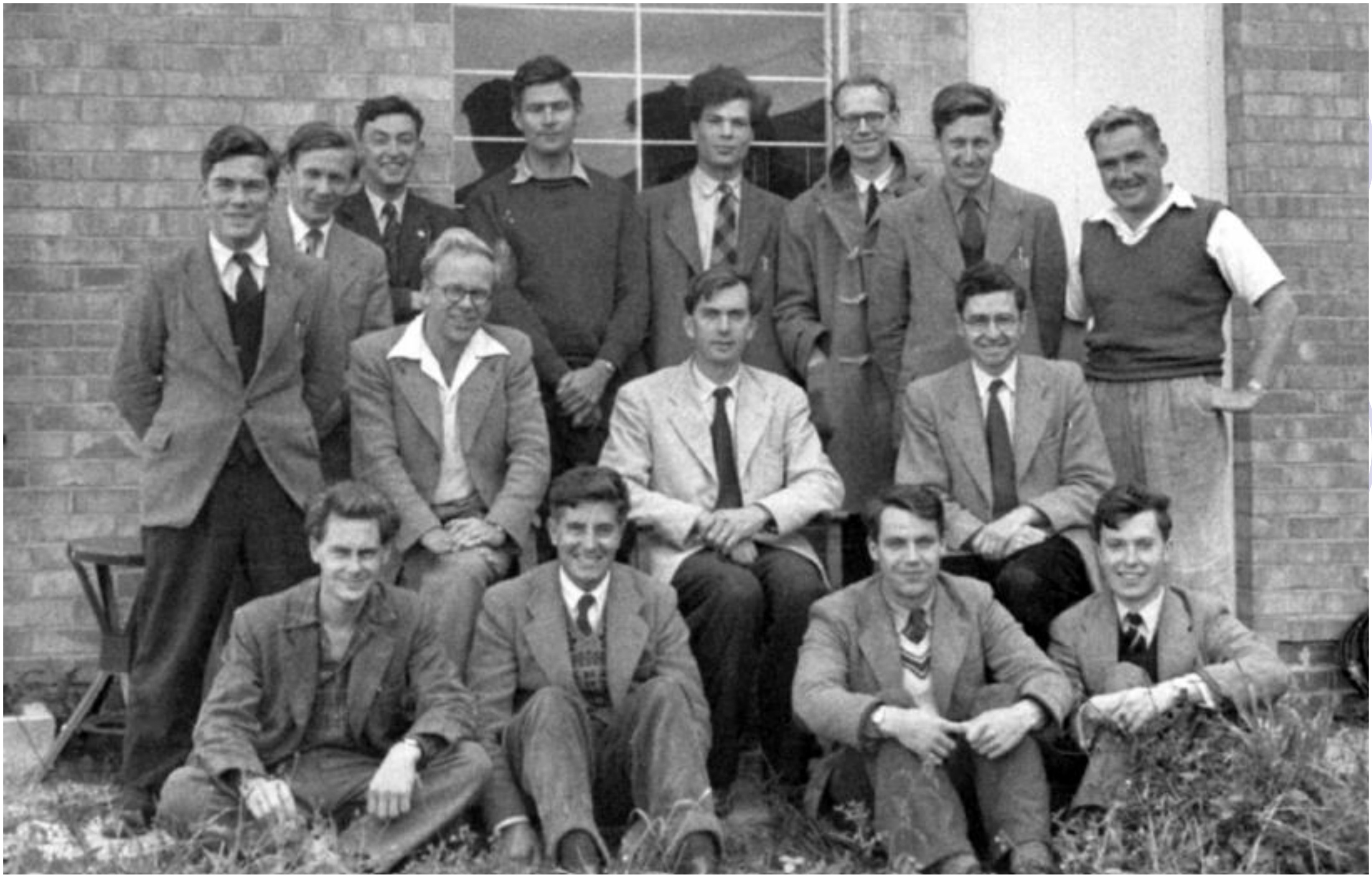
Graham Smith measured position of Cas A with phase-stable interferometer

- Cambridge used interferometers of relatively short baseline before 1960
- Jodrell experimented with longer and longer baselines and used radio links to transmit signals
- Jodrell aimed for high angular resolution

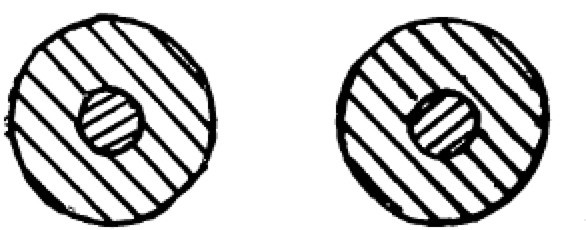
The Cambridge group did much work on source positions

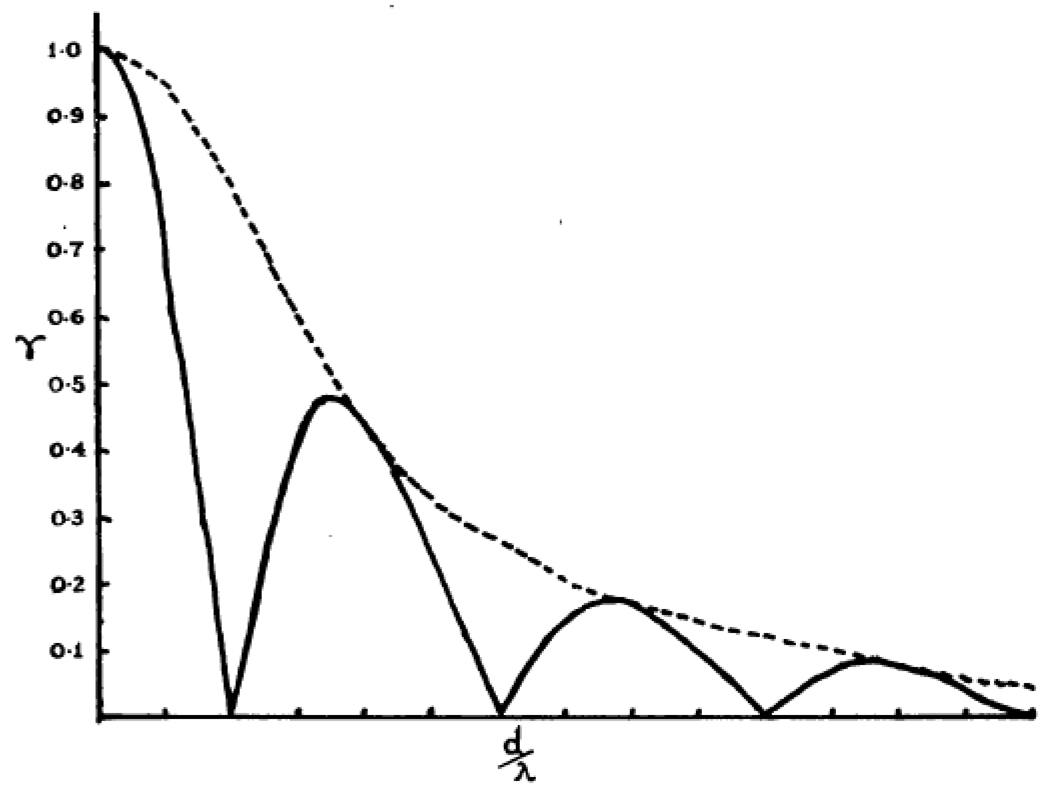
- This was essential for identification of optically faint radio sources
- Jodrell pioneered long-baseline interferometry, where determination of phase was challenging
- Jodrell hence depended heavily on fitting model brightness distributions to visibility amplitudes to determine source structure
- Ryle in particular questioned the uniqueness of the brightness distributions so obtained

The Cambridge group in 1954

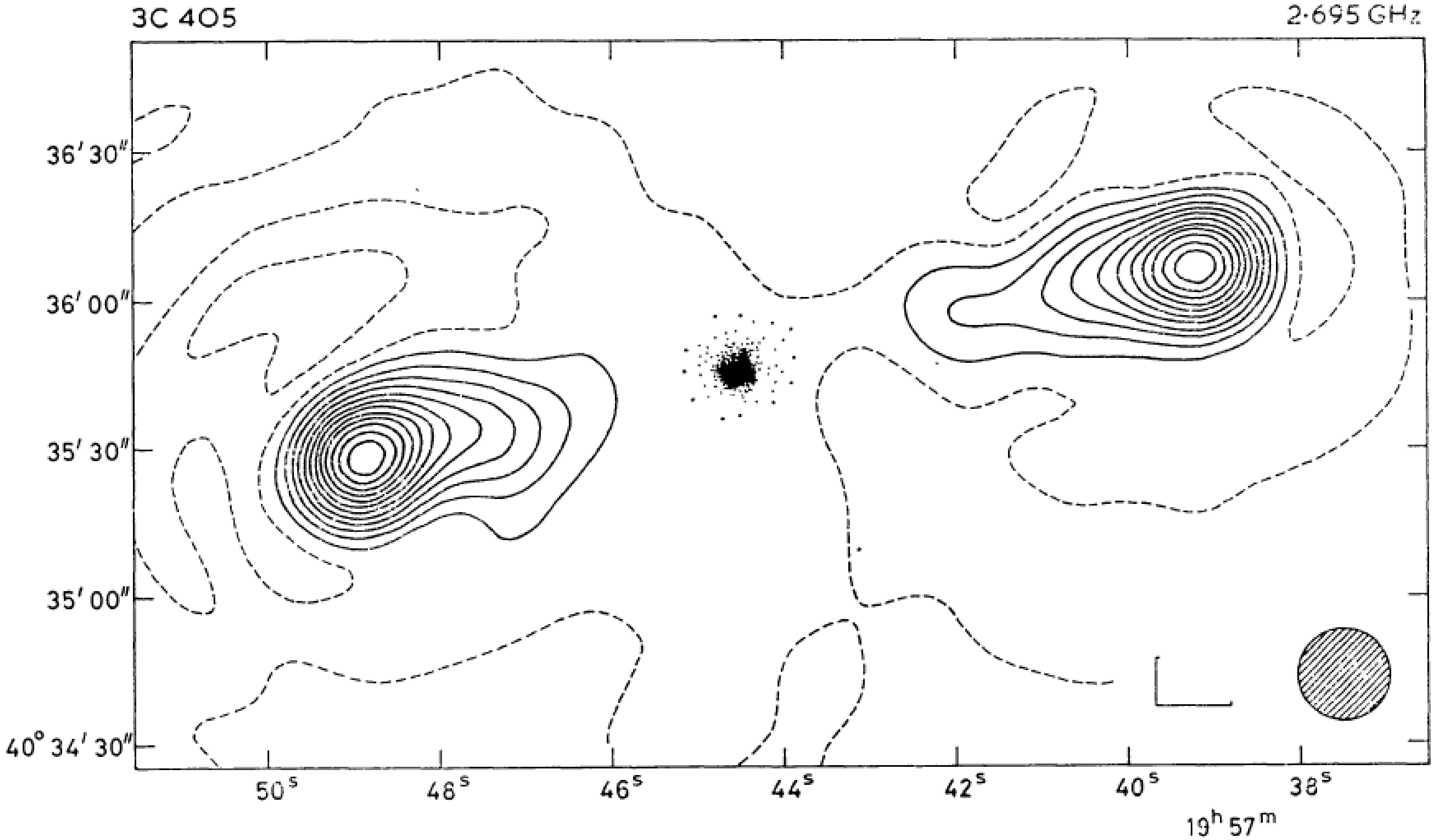


Double radio source and its visibility (Allen, Hanbury Brown & Palmer, 1962)

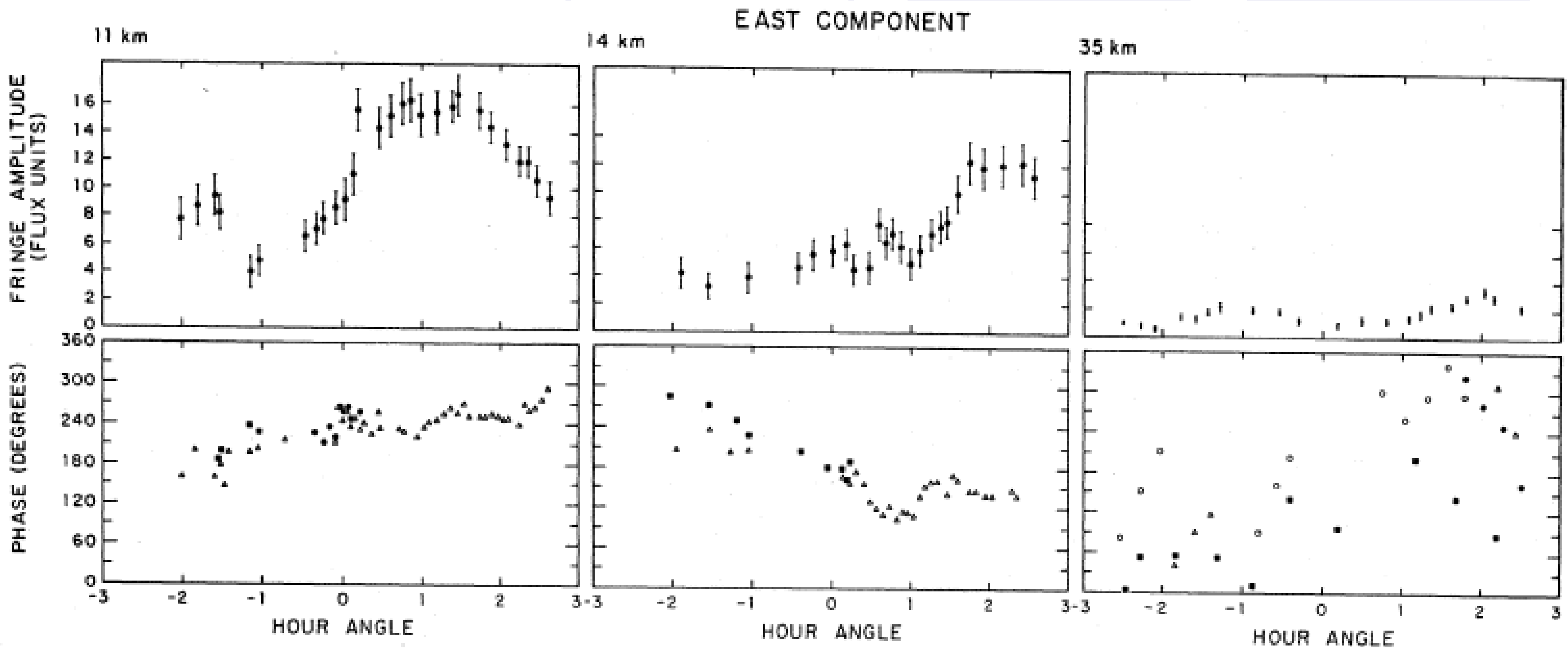




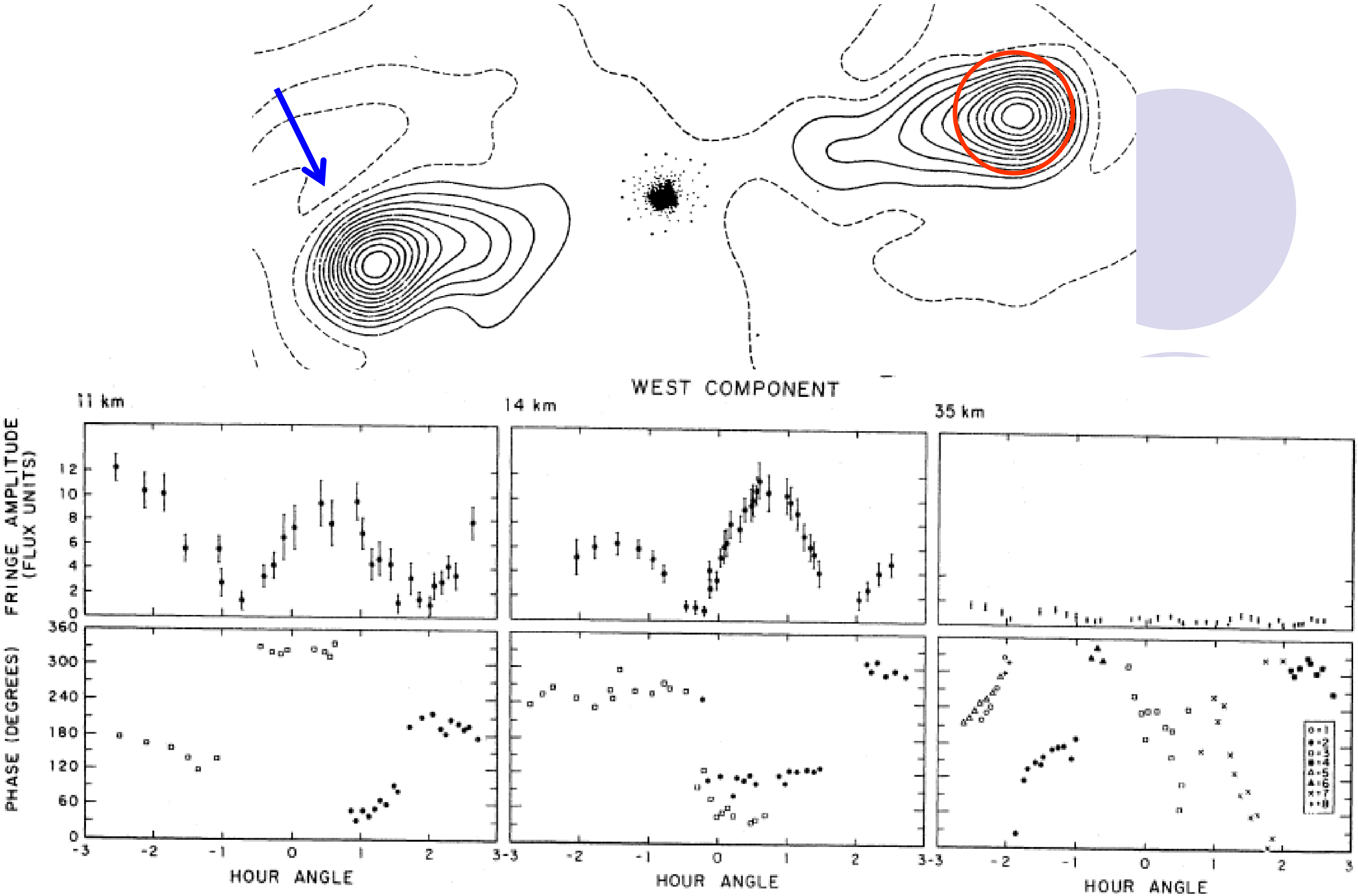
Cygnus A, OMT, Mitton & Ryle (1969)



Fine-scale structure in Cyg A (Miley & Wade, 1971)

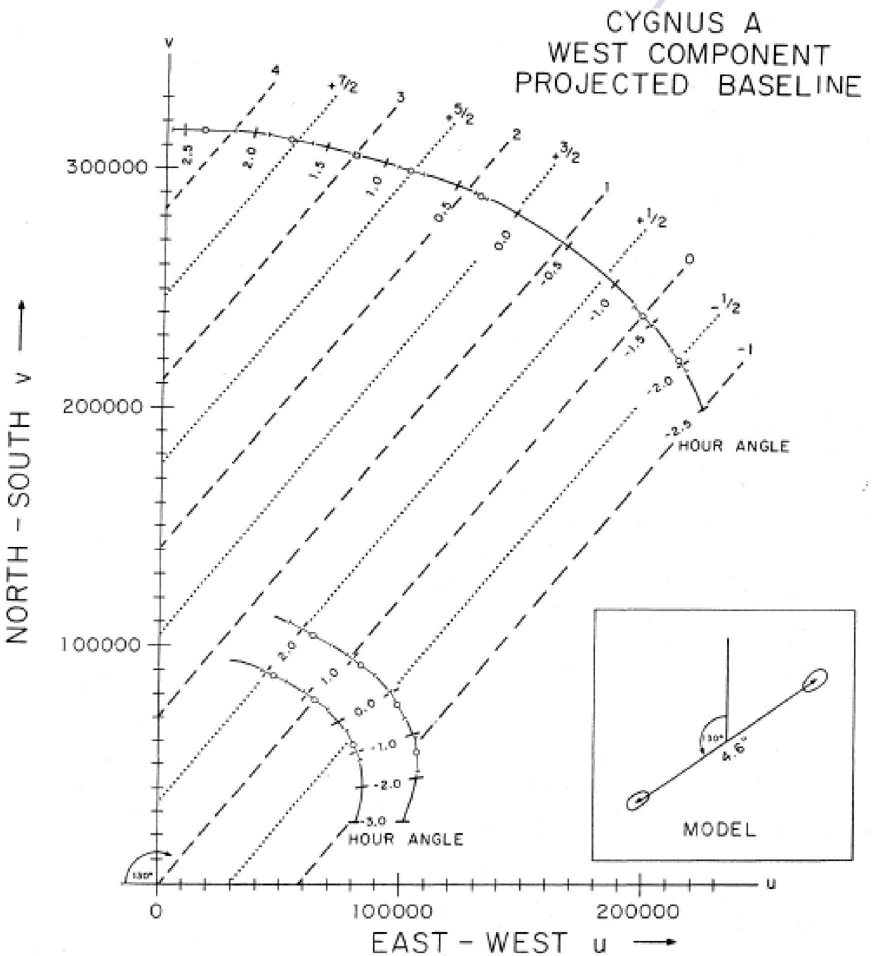


Cyg A (west)



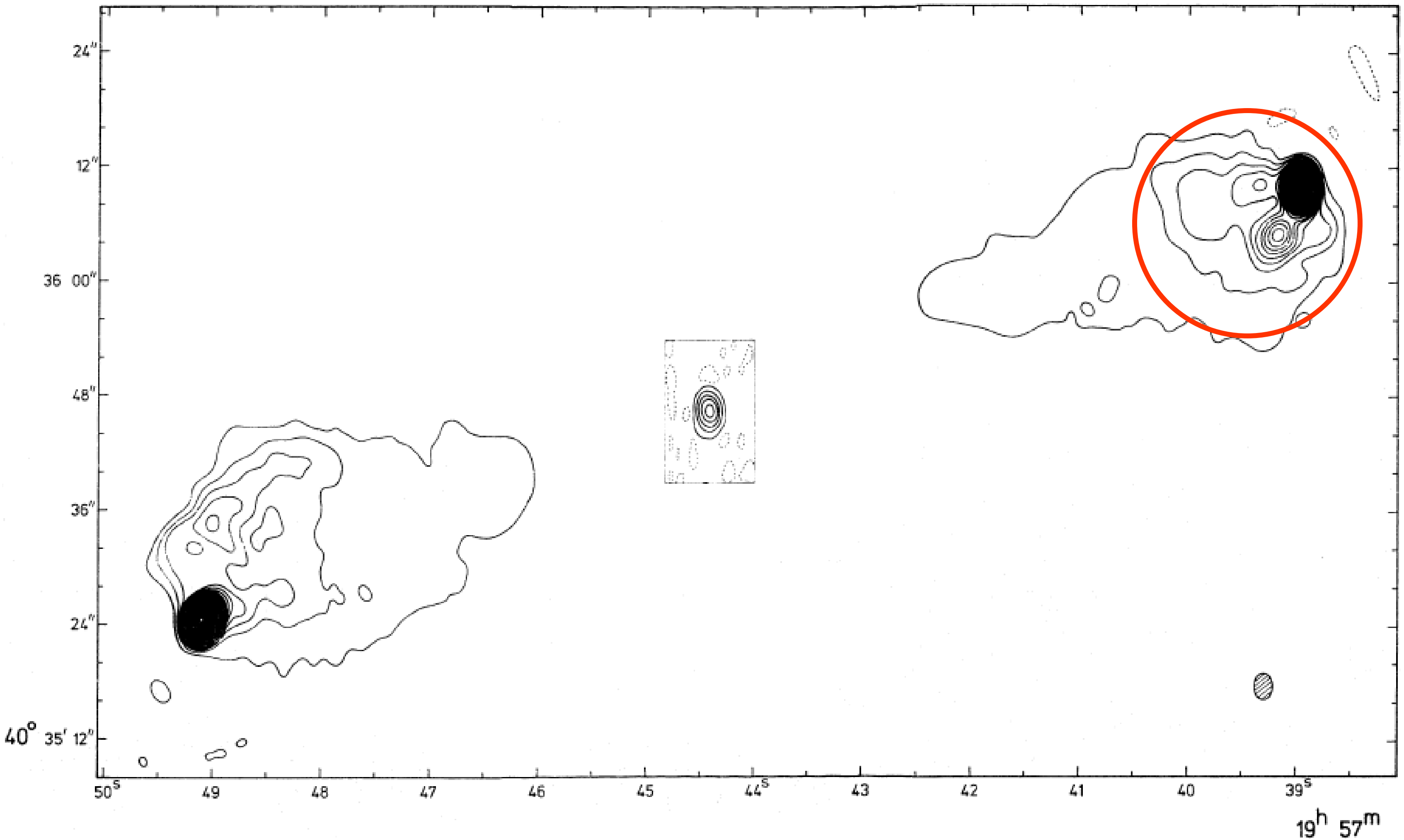
WEST COMPONENT
11 km
14 km
35 km
FRINGE AMPLITUDE (FLUX UNITS)
PHASE (DEGREES)
HOUR ANGLE
HOUR ANGLE
HOUR ANGLE

The Miley & Wade model fit to the west component of *Cyg A*



- 2 hot spots, 4.6” arc apart, p.a. ≈ 130°
- Roughly equal flux density
- Size ≈ 1” arc
- SE probably the stronger

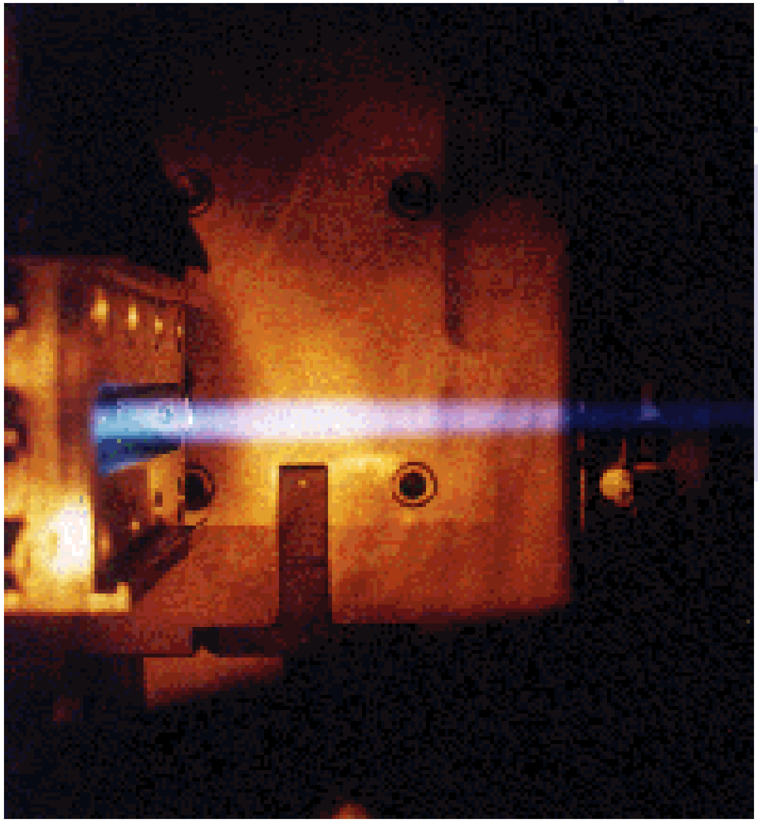
Hargrave & Ryle (1974), Cyg A, 5kT, 5 GHz



Synchrotron emission suggested in: "Cosmic Radiation and Radio Stars"

- By Hannes Alfvén & Nicolai Herlofson
- Physical Review, 1950
- "Radio stars" would emit by high energy particles in strong stellar magnetic fields
- It was soon suggested that continuum emission from the Crab Nebula might be synchrotron

This radiation first seen (1946) as light in synchrotron accelerators; the radiation is strongly polarized



When was “synchrotron radiation“ first used in astrophysics?

COSMIC MAGNETOBREMSSTRAHLUNG (SYNCHROTRON RADIATION)[1,2,3]

By V. L. Ginzburg and S. I. Syrovatskii
P. N. Lebedev Physical Institute, Academy of Sciences, USSR, Moscow

- “We note that the term “synchrotron radiation” arose by chance and seems to us an unfortunate selection. Therefore, we have used broadly… the more meaningful term “magnetobremsstrahlung.” However, it hardly seems possible at this late date to change the accepted terminology…” (1969)

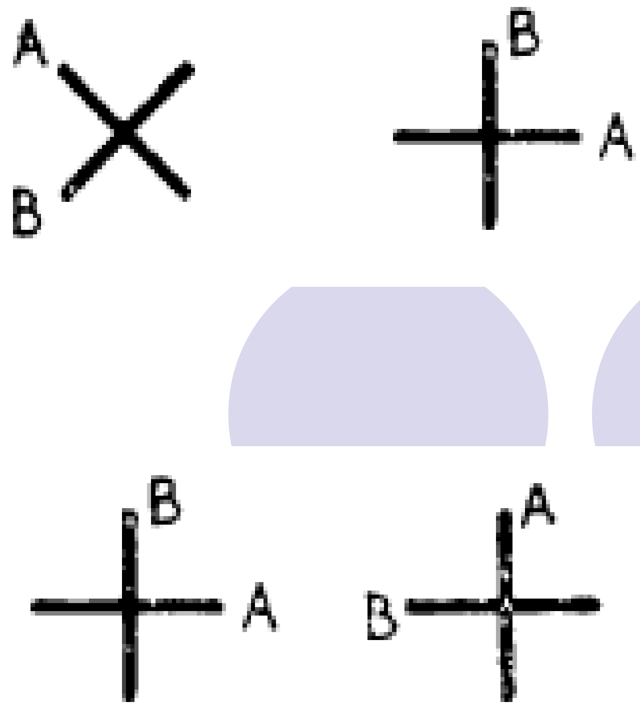
Prof. Oort regularly used term "synchrotron radiation"

- This was notably so when discussing the Crab Nebula continuum emission
- In their article on the polarized emission from the Crab Nebula (Oort & Walraven, 1956) the term is frequently used
- The earliest mention I have found is to the "synchrotron mechanism" in a piece (in Dutch) from December 1955.
- Oort was certainly one of the earliest users

From the start, the WSRT could measure polarization

- The WSRT had very stable receivers
- Kurt Weiler suggested correlating horizontally and vertically oriented dipoles with feeds rotated by 45° (this enabled ready amplitude and phase calibration)
- With a stable system (better than 20 dB) Stokes Q and U could be determined to 1%
- Other instruments observed twice for good determination of Q and U

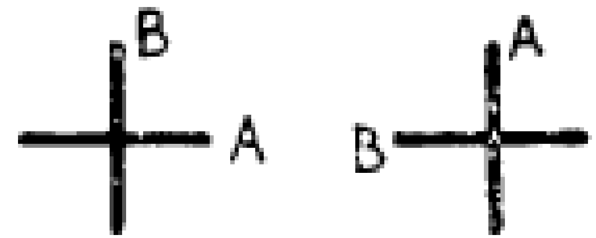
As long as the WSRT only correlated "fixed" with "movable" elements, it was ok.



- But when all feasible correlations became possible – improving sensitivity and enabling redundancy – it made sense to have all dipoles parallel
- Even more so when the MFFEs came online

However, there was a calibration problem

- The B*A and A*B would be well calibrated
- But you still needed a way to link the complex gains of A & B systems
- A polarized calibrator would be ideal, or…?
- Calibration of VLBI was also a concern



Thank you

Dank je wel

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