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LONG-BASELINE INTERFEROMETRY

SUMMARY OUTLINE

(The numerals in parentheses after some of the entries are references to the bibliography appended to the outline.)

I. Introduction: Historical Background

A. Developments in optical astronomy (8, 9, 10, 36).

1. Growing appreciation of the astrophysical importance of the role played in galactic evolution by events in galactic nuclei.
2. Recognition of the profound theoretical problems involved with the existence of violent activity in galactic nuclei; consequent demand for observations to help understand the nature of these events.
3. Inadequacy of optical methods for resolving the structures of interest; optical intensity interferometer (23).

B. Developments in radio astronomy (3, 4, 30).

1. Discovery of discrete sources; the cliff interferometer at Sydney.
2. Implications of non-thermal spectra and secular changes in flux (31, 28).
3. Attainment of increasing resolution by conventional interferometric methods.
    a. Aperture synthesis (5, 33)
    b. Post-detection correlation (24)
    c. Radio-link interferometry, Jodrell Bank to Malvern (21, 1)
    d. Limitations
4. Other methods for observing compact structure, and their limitations (15).
    a. Lunar occultations, scales to about 8" (25, 27)
    b. Interplanetary scintillation, scale sizes near 0".2 (18)

II. VLB Hardware

A. The typical system: essential components.

1. Conventional interferometer hardware from front end through i-f amplifiers.
2. Independent time and frequency standards; usually maser, rubidium vapor frequency standard, or crystal oscillator.
3. Multiplexing device to combine signal data with synchronizing signals.

4. A medium on which the data stream can be preserved, usually magnetic tape.
5. A correlator for the data streams from the various observing stations.
6. Conventional post-correlation processing machinery to average results, calculate correlation coefficients, correct and edit the data.

B. Some actual systems that have contributed important observations.

1. Florida system: first tape-recorder interferometer; low frequency, low bandwidth, poor sensitivity; originally operated with post-detection correlation, later converted; observed decametric emission from Jupiter (11).
2. Canadian system: first pre-detection (Michelson) tape recorder interferometer; video tape recorders with analog data format (7,19).
3. U. S. systems (developed by Barry Clark and others at NRAO)
   a. Mark I: 360 kHz bandwidth, maximum length of continuous observation about 200 sec.; digital recording on standard half-inch computer tape using a conventional tape drive (2, 19).
   b. Mark II: 2 MHz bandwidth, continuous observations up to three hours, recorded digitally on 2-inch video tape (13).

III. Types of Observing Programs

A. Continuum.

1. Source structure (emphasis primarily on extragalactic objects).
   a. Surveys (6, 12)
   b. Morphology (14)
   c. Secular changes in flux and structure of compact components, sometimes monitored by long-term observing programs (Quasar Patrol, FOG) (17, 35)
   d. Emphasis on short wavelengths and extreme resolution, 0"001 and smaller
2. Astrometry (20, 26, 16).
   a. Source positions, absolute coordinate systems, ray bending (relativity)
   b. Geodesy: baseline measurement, earth rotation rate, polar wandering, continental drift

B. Spectral lines (principally OH and H_2O), generally in galactic sources (29).

1. Source structure and variability.
2. Radial velocity as an additional dimension in the analysis.

C. Pulsars: size, proper motion, and pulse shape (34).

D. Nearby stars: novae, flare stars, binaries, and so on.

E. Coherent man-made sources: for example ALSEP transmitters on the moon, aircraft, enemy radars.

IV. Principal results of the continuum observations of source structure

A. Existence of compact structure over a wide range of scale sizes in numerous extragalactic sources.

B. Secular changes in structure and flux of the compact components, often on time scales of months, sometimes correlated with substantial changes in the total flux; effect most pronounced at short wavelength and high resolution, as one would expect (32, 35).

C. Unexpected complexity of the sources.

V. Shortcomings of present techniques

A. Inadequate sampling in the transform plane.

B. Difficulties involved with scheduling and carrying out observations: personnel, telescopes, receivers, and so on.

C. Loss of visibility phase information as a result of local-oscillator instability; consequent inability to recover the source brightness distribution unambiguously.

D. Excessive time required to interpret a set of observations, particularly when multiple baselines are involved.

VI. Anticipated developments

A. Third-generation recording and playback systems having better reliability, more bandwidth, greater flexibility, and faster processing.

B. Satellite-link VLBI.

C. Dedicated VLBI array.

1. More extensive and more uniform sampling in the visibility plane.
2. Antennas better suited to the requirements of VLBI observations.
    a. Observations to 1 cm wavelength
    b. Full sky coverage
3. Continuous availability and convenient scheduling.
4. Routine operation.
5. Automated processing.

D. Improved algorithms for recovering source brightness distributions.

ECLECTIC BIBLIOGRAPHY

OF LONG-BASELINE INTERFEROMETRY AND RELATED TOPICS

One or two representative papers have been chosen from the (possibly extensive) literature on each of the topics included. I have tried to choose papers that give an exceptionally clear or thorough treatment of the theoretical background and experimental techniques employed, as well as some of the classic papers in which novel ideas or results first appeared. Probably the best single reference on VLBI is Cohen's review paper (15).

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