3-II A1

THE DESIGN STUDY OF A SUPERSYNTHESIS ANTENNA ARRAY**

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Introduction

Supersynthesis is a powerful interferometric technique to sample a large number of spatial frequency components of a radio-astronomical source. It involves using different interferometer baselines and letting their projections on the spatial frequency plane vary through earth rotation. The loci of these projected baselines are called baseline-tracks.

Many interferometer pairs may be formed in an antenna array. With a given number of elements, a good array configuration may be defined as one for which the baseline-tracks sample the maximum number of relevant points on the spatial frequency plane. The set of sampled points is called a transfer function [1].

The design of a good array configuration is difficult because the supersynthesis technique involves many parameters. These include the length of tracking time, the track sampling rate, the source declination, the array latitude and all the element locations in an undefined planar array configuration. To overcome this difficulty, N.R. Mathur tried a 'pseudodynamic programming' approach [1] with good but restricted results. Our investigation is an analytical approach, isolating and separately optimizing the influence of different parameters on the sampling of spatial frequency components. This approach requires a detailed study of the mechanism of supersynthesis, but it gives a good array design without the help of a computer. Extensive computations are used only to check the spatial frequency results.

Design Steps

A design study using this approach may be summerized in the following steps:

(1) Array-arm configuration: Four array configurations have been singled out for comparison [2]. Even with nonuniformly spaced elements, the Y array was found to be most promising.

(2) Array-arm lengths and their azimuth directions: A study, on the projected baselines, reveal that there are two types of foreshortenings in the supersynthesis process. Compensations for these foreshortenings result in array arms oriented as shown in Fig 1.

(3) Element locations along array arms: This step is based on the assumption that the most efficient use of the baseline tracks is to distribute them evenly over the required transfer function area. A study shows that such distribution is obtained by a square-law location of elements.

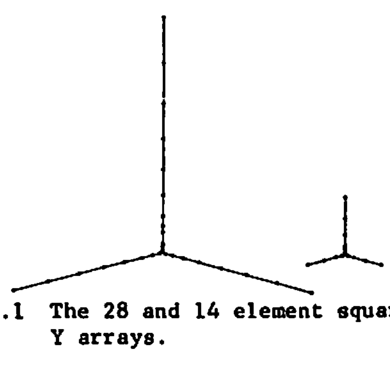

Fig.1 The 28 and 14 element square-law Y arrays.

**This work was done during the 1970 summer in the National Research Council, in Ottawa, Canada.

(4) Two array examples: Figure 1 shows two arrays of the square-law Y design.

(5) Computer simulation of tracking by the array: For display and digital data handling, the sampled points of the transfer function are grouped into cells, and the cells are formed by square grids over the spatial frequency plane. The cell size is inversely proportional to the array field of view in accordance with the sampling theorem for grating lobes. The minimum sampling rate of the array is that which gives at least one sampled point per cell, even for the longest baseline-track, so that no tracks will miss any cells on their paths.

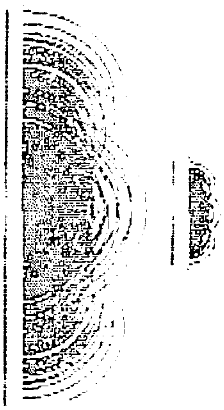

Fig.2 Half of the transfer functions for the two arrays. $\delta = 30^{o}$. Tracking time - 4.4 to +4.4 hours.

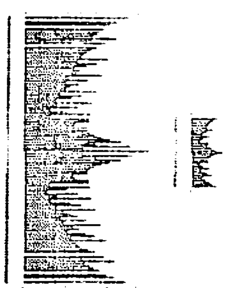

Fig.3 Half the transfer functions for the two Y arrays. $\delta = 0^{o}$ Tracking time -5.0 to +4.0 hours

With the tracking parameters decided the two arrays in step (4) are simulated by the computer. Four of their transfer functionsare displayed in Figs. 2 and 3.

Discussion

The analytical approach to the array design has resulted in the square-law Y array. Because of the detailed understanding of the geometry involved in each design step, it becomes evident that this design is nearly optimum, both in the number of sampled points and in the even distribution of these points at any source declination.

The most desirable feature of the square-law Y array is its ability to grow and grow in a square-law fashion. Figs. 2 and 3 have shown that by simply doubling the array elements, the number of sampled cells in the transfer function is increased 16-fold. This 16-fold increase may not be so surprising if we made the following observation. A doubling of array elements will cause a quadrupling of the number of baselines. Through the square-law array design, this will also cause a quadrupling of array arm lengths. In turn this means a quadrupling of the baseline-tracks and required a quadrupling of minimum sampling rate. This double quadrupling of baselines and sampling rate gives a 16-fold increase in the sampled cells in the transfer function.

The synthesized array power pattern is the Fourier transform of the array transfer function. Hence, with the same array field of view, a doubling of array elements means a 16-fold decrease in the area of the synthesized main beam of the array.

References

1. Mathur, N.C. 'A pseudodynamic programming technique for the design of correlator supersynthesis array.' Radio Science, 4(3): 235-243; 1969.

2. Chow, Y.L. 'A comparison of some correlation array configurations for radio astronomy.' IEEE Trans., AP-18 (4): 567-569; 1970.