VLA

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ELECTRO-OPTICS SECTION

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National Radio Astronomy Observatory
Edgemont Road
Charlottesville, Virginia 22901

ATTN: Dr. L. Somers

SUBJECT: Monthly Report for August 1976
VLA Optical Processor
Contract: VLA-215

1.0 SUMMARY

Work during August consisted of a continuation of Task 1 of the three tasks making up the program. We feel that Task 1 is essentially complete and requires only a consolidation of the results obtained thus far, which will be accomplished in September. August activities are summarized below.

The analysis of the optical channel configuration and the degradation of the Fourier transform of signals which exhibit phase errors was continued. Gaussian weighted signals were incorporated in the computer program for phase error affect analysis. A corrective calibration scheme which uses a simple re-normalization (multiplier) was examined briefly with the intent of this approach being minimization of the affects of phase errors. An analysis relating input data phase errors and optical ray aberrations was completed[1]. A theoretical assessment of fundamental properties of off-axis diffraction was started with the objective of determining if phase or amplitude errors exist for which compensation must be provided for the reference beam case.

Investigation of the encoding and formatting requirements for recording of u,v plane data was continued. The results to date suggest (a) that u,v plane data be recorded as optical transmission variations rather than phase[2], (b) that the data be

written in analog form on a carrier frequency, and (c) that the recording scan format will likely be that of writing on elliptical paths, although a rectangular scan format offers the more convenient approach from the recorder design point of view.

The preliminary experimental evaluation[3] of output detector arrays, and a survey of available devices[4,5], was completed. The Reticon detector was selected over the Fairchild device mainly because the Fairchild device has poor response at saturation in terms of adjacent cell spill-over.

An analysis of the detection and sensitivity properties of the output detector on the output signal levels (signal and reference beams) and on output signal calibration was performed[6]. Results thus far suggest that for peak signal-to-noise ratios of 10^3 and with a reasonable range of signal-to-reference beam ratios (1/2 to 3) a calibration accuracy at least as good as 1% can be achieved on the peak signal in the sky map. Further analysis of this subject will be made on an experimental and theoretical basis as the program continues. A theoretical analysis of the affects of sampling with the detector array which shows the smoothing and replicating effects of the sampling function has been completed[7].

Test gratings for use in examination of the optical processing channel off-axis operating properties were completed[8], and will be used in the component testing phase during build-up of the breadboard processor.

Though quite late relative to our needs, we received a letter[9] from the lens design consultant, John McDonald, of the University of Reading, England. He expressed an interest in

pursuing an optical design analysis and stated a need for further clarification of the optical channel performance requirements. This information is being prepared and will be sent to him in the immediate future. A response from Dr. McDonald as to the cost and an explanation of his proposed effort will be required before he can actually begin work.

2. REQUEST FOR START OF TASK 2

It is expected that Task 1, Initial Analyses, will be completed by early September. To assure continuity and efficient staffing of the program, it is requested that approval for the start of Task 2 be given by 21 September.

Task 1 has served to establish the direction for Task 2 on an analytical, and in part, experimental basis. Task 2 will provide an in-depth assessment of a design approach for a VLA Optical Processor System with emphasis being given to critical aspects of the system.

Briefly, with regard to the more critical design considerations, Task 1 activities provide the preliminary conclusions: (1) that a recorder using amplitude transmission encoding of u,v plane data on a carrier with elliptical path scanning would be used, (2) a beyond-the-lens optical processing channel with a reference beam would be used, (3) that a composite detector array providing about four samples across the point spread function width (between zeroes) would be used, and (4) that system phase errors which can vary from data frame to frame, and which are therefore not readily compensated, must be kept below about twenty degrees RMS or one-fiftieth of a wavelength peak-to-peak in order to satisfy the one percent accuracy

requirement on the sky map. The major source of such varying phase errors is expected to be the recorded input data as caused by recorder scan uncertainties and film surface non-uniformities.

3. INFORMATION NEEDS

As part of an on-going interpretation of the interface between the radio telescope and the optical processor system we have a need for the following information at this time:

(a) A nominal value, or range of values for the ratio of "maximum of the absolute value squared" of the sky map to the "mean of the absolute value squared" of the sky map.

(b) The nominal value or range of values for the ratio of the "mean of the absolute value squared" of the u,v plane signals to the "maximum of the absolute value squared" of a u,v plane signal.

(c) The width of the dirty beam amplitude measured between its first zeros and also measured at 50% down from its peak (Accuracy $\leq$ 5%)

(d) Same as (c), except for a hypothetical full aperture antenna having a diameter equivalent to that which gives the largest u,v plane track normally obtained with the VLA (Accuracy $\leq$ 5%)

(e) A detailed table of numbers or a continuous graph of cross sections of the dirty beam. The data should allow an accurate interpretation of the dirty beam (i.e., < 1%).

1. Relating Phase and Ray Aberration Error, ERIM memo, 7 September 1976, C. Aleksoff.

2. Phase Modulation Encoding, ERIM memo, 2 September 1976, J. Fienup.

3. ERIM memo in preparation, R. Dallaire.

4. Preliminary Detector Array Evaluation, ERIM memo, 1 September 1976, R. Dallaire.

5. Reticon Information Summary, NRAO memo, 23 August 1976, R. Harrison.

6. Optical Processor Detection Characteristics, NRAO memo, August 1976, R. Harrison.

7. Sampling Considerations, ERIM memo, 8 September 1976, C. Aleksoff.

8. Construction of Precision Low Frequency Gratings, ERIM memo, 1 September 1976, C. Leonard.

9. Letter of 12 August 1976 from J. McDonald of the University of Reading, England, to L. Somers and I. Cindrich.