VLA TEST MEMORANDUM 110

Results from Interferometer Testing, Phase I. (February 18-March 25, 1976)

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June 1976

I. Introduction

Interferometer first fringes were found on February 18, 1976. From then until March 25, there was a 40 hour observing session every week, for a total of six sessions. Most of the time was spent in debugging, but a few salient facts have emerged. These are given in Section II. Section III is devoted to items of historical interest, problems which have been overcome. Section IV covers problems whose status is indeterminate; that is, it is unclear whether the problem is one of repair or redesign, or whether the problem has been fixed or not. Section V mentions some measurements which did not yield a definitive answer.

All tests in Phase I were made with the A IF only and only at 6 cm wavelength. Polarization was linear. All tests were made with Antennas 1 and 2, stationed, respectively, at CW5 and CW9, a baseline of 1.23 Km (fringes of 10"). No attempt was made to close the LO phase loop from the measured round trip phases, nor was any attempt made to correct amplitudes for system gain, measured by the switching noise source. The principal work of each session is given below:

February 18 - Find fringes, make computer drive delays, fringe generators, and phase reversers to get stopped fringes.

February 25 - Digital data recording, interferometer mode pointing measurements made to work.

March 2 - Attempt at pointing #2, amplitude stability, sidelobe levels, phase measurements.

March 8 - Attempt at pointing #2, amplitude stability.

March 15 - #2 pointing constants derived, pointing check on #1, amplitude stability, blank sky observations.

March 22 - Delay constant determination, beam shape measurement, blank sky observations, #2 pointing check, Bx, By determinations.

II. Measurements of lasting interest

The number actually processed by the computer system is normalized correlation coefficient. That is, if we have two voltages, A and B, and denote the averaged product of A and B by A•B, then the quantity we compute is

$$c = A \cdot B \; / \; \tfrac{1}{2} \, (A \cdot A + B \cdot B)$$

Theory indicates that, in the 3 level case, this should be a reasonable estimate of the true correlation. By varying the power going into one of the two samplers, the curvature of the plot of the number c against the true correlation coefficient may be obtained. The curve peaks at the expected place, and the curvature is such that a 0.25% peak error is seen over a range of slightly more than 10% in input power.

It has become clear that feed pointing is much more critical affair with a cassegrain antenna than with a prime focus feed, and especially for an offset cassegrain. If the center of illumination is offset from the dish optical axis by more than about 20 cm, it introduces highly undesireable phase changes across the beam. It will, in the future, be necessary to measure this quantity and adjust the feeds accordingly as a standard calibration.

An accurate set of measurements of the first few sidelobes was made. Because the effect of subreflector blockage is to subtract from the voltage beam pattern that of a dish the size of the subreflector, blockage will increase the size of the antiphase sidelobes (odd numbered ones) and decrease the size of inphase sidelobes (even numbered). The typical measured sidelobes are given below:

Sidelobe	Power	db	$(2J_1(x)/x)^2$
1	.048	-13	.017
2	.002	-27	.004
3	.003	-26	.0016

Under the best of circumstances (no hardware faults, high in the sky), the amplitude stability of the measurements is very good, better than 1% rms in the short term. If a simple 0.055 sec z correction (to approximate the increase of the system temperature due to atmospheric radiation) is applied, the long term amplitude stability is about 4% rms. In determining this, ratios of fluxes of a few calibration sources were obtained. These can be reduced to Janskys by assuming 3C286 = 7.5 Jy. We have

Source	Flux		Pauliny-Toth and Kellerman (1968)
0106+01	3.36		2.43
3C84	40.3		18.7
0727-11	3.68		
OJ287	2.39		
1127-14	5.5		7.31
3C286	7.50	(assumed)	7.5
3C309.1	3.34		3.76
3C345	8.3		5.6
3C395	2.02		1.81
2145+06	6.1		4.71
3C454.3	10.7		19.7

Since most of these sources are highly variable, the discrepancies are not unexpected.

A preliminary set of baseline parameters is available. To avoid confusion, it is quoted as per after the resetting of the pedestals of CW5, and after correction for a minor software error, both corrections being made after the end of the phase I tests. The parameters are quoted in terms of the locations of the two telescopes. Note that adding a constant to both telescope positions in the same coordinate does not change the baseline. The particular parameters chosen are such that the zero of the coordinate system lies near the array center. These numbers are presumably comprised of a station location and a telescope offset; however, it is not possible to separate the two until several telescopes have occupied a previously occupied station.

	#1	#2
Bx	747.20	2040.74
By	-1962.82	-5281.34

It may also be noted that these are instantaneous geocentric coordinates. The conversion to the Conventional International Origen has not yet been applied.

III. Problems overcome

A large number of entries could be made under this classification of minor software errors. These are not of even historical interest and will not be mentioned when the problem has been fully corrected, nor will module failures be mentioned if they are not part of a general pattern.

A great deal of time was wasted trying to properly point Antenna 2, when it was eventually found that a loose bolt in the elevation encoder was resulting in a large hysteresis effect.

The correlator system controller appeared to be receiving observing parameters at times when the software was not sending them. The problem was solved not by locating the source of the erroneous data, but simply by having the system controller perform a few integrity checks and ignore data that do not satisfy them.

Due to a not-very-inspired choice of observing card format, it was easy to accidentally change frequencies. There was no place on the cards to specify bandwidths. Also, the reconfiguration of the array into subarrays (a feature not yet implemented) was not convenient. The observing request card format has been redesigned and, at this writing, the new design has just been implemented.

IV. Problems which are yet with us

The pointing of the telescopes, as stated in Test Memorandum 109, is not as good as it should be for operation at 1.3 cm wavelength. The errors appear to be worse in elevation than in azimuth and worse in the day than at night. The new design of the encoder enclosurers may alleviate the problem, or it may not. The causes of the errors must be found and, if possible, either corrected or measured.

The digital communication system has not been error free or reliable. Substantial improvements were made during April, but the error rates are still more than an order of magnitude higher than the acceptable levels.

The switched noise tube, as currently set up, cannot be used for system gain determination. In order that the detector amplifier remain unsaturated at the high frequencies, and to preserve a reasonable margin for gain variations and strong sources, the output voltage for C band must be set at about 1 volt. band edges, or if the gain drifts down, it is substancially less than 1 volt. The A/D converter errors (systematic as well as truncation) then amount to nearly 1%. A possible way out is to space the existing gain controls more rationally. There are three steps: DC amplifier low gain, IF splitter attenuator, and paramp pump off. If these are respectively selected to be 7 dB, 15 dB, and 30 dB, we can cover all situations without excessive truncation errors.

V. Inconclusive measurements

The phase measurements have been so limited by LO system problems that no estimate of phase stability could be made.

There is insufficient experience to indicate whether we have relibility problems or burn-in problems, in several areas.

No measurements of polarization properties have been made.

No significiant interference at 6 cm has been encountered, except for an internally generated 4800 MHz. However, 21 cm is far more critical for interference problems.

The blank sky noise appears to be about as expected, except that there remain a few uncertainties in the calculation, and there is a systematic offset due to truncation in the correlator and computer.