25 Meter Millimeter Wave Telescope Memo # 105

Interoffice

NATIONAL RADIO ASTRONOMY OBSERVATORY

TUCSON, ARIZONA

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To: 25-Meter Telescope Design Committee

From: B. L. Ulich

Subject: Surface Measurement

I want to propose an alternative scheme for measuring the surface of the 25-meter telescope. If the panels have been mechanically measured prior to installation, the only further requirement is to measure their relative axial positions on the telescope. This can be done electrically by the principle of microwave holography. Basically one can infer the aperture phase distribution of an antenna by scanning its beam and measuring the amplitude and phase of the signal received from a strong source. In practice a transmitter can be located at least as close as 0.1 D^2/λ since the curvature of the spherical wave emanating from the transmitter can be corrected by slightly defocusing the receiver feed horn from its normal position. The phase errors in the aperture plane may be directly related to the mechanical adjustment errors in the surface panels. The accuracy of surface measurement depends mainly on the wavelength, on the signal-to-noise ratio of the phase measurements, and on the maximum scanning angle.

In order to clearly define individual panels, we require about four resolution elements to be included in the smallest panel dimension. Thus for one meter panels, the surface resolution element will be about 1/4 meter, or D/100 for D=25 meters. This resolution can be achieved by scanning the beam $\pm$ 50 λ/D and by sampling every 1/2 λ/D. Thus a 200 x 200 array of amplitude and phase data is required to be Fourier transformed, and this can be done with only moderate computing power.

Atmospheric amplitude and phase scintillations may be minimized by comparing the received signals with those from a fixed reference antenna. At 3 mm wavelength a 20 dB S/N ratio in the comparison data will produce a best possible surface plate setting accuracy of 15 μm. I believe a practical system could achieve an accuracy only a factor of two or three larger than this, which would be adequate for our purpose. Of course, this method could (and should) be verified experimentally. Centimeter wavelength systems have been successfully operated in England, but our more stringent accuracy requirements necessitate further work before such a scheme could be considered as the sole method of setting the telescope panels.

As mentioned previously, the beam must be scanned about 50 λ/D off axis, which corresponds to about 42 half-power beamwidths. At 3 mm wavelength this maximum scanning angle is about 0.4^o. If a transmitter were located on Mauna Loa at a distance of 41 km ($0.20\ D^2/\lambda$) and at an elevation angle of -0.5^o, then the telescope must have an unobstructed view down to -0.9^o elevation in that direction. Mauna Loa is clearly visible from the telescope site recently chosen on Mauna Kea, and the only fundamental difficulty with implementing this method is the 0^o elevation limit of the current telescope and astrodome design. I suggest that the slight increase in cost to achieve -1^o elevation coverage would be worthwhile in view of the significant advantages of pattern range availability.