MILLIMETER ARRAY
MEMO NO. 26

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Dear Frazer:

Millimeter Array Memo 22 relies on a number of implicit assumptions made with the laudable intention of quantifying the array parameters. Some of these assumptions, however, are inconsistent with the realities of millimeter observing in a way which substantially modifies the conclusions in favor of smaller antennas.

Consider the following project: we wish to map a 1′ diameter field of a galaxy in the J=2→1 line of CO. Suppose we use two equally costly arrays — 30 6-meter antennas, and 6 20-meter antennas. Which array is faster? (I stipulate for the moment that the beam efficiencies are comparable and that the 20-meter antennas can all actually be pointed to the required 2" accuracy.) The 6 20-meter antennas are 2.5 times more sensitive than the 30 6-meter antennas, so that each primary beam area can be observed 6.25 times faster. However, our 1′ area can be covered by a single primary beam of the 6-meter antennas, while the 20 meter antennas must mosaic at least 10 points. The array of 30 6-meter antennas cover the field almost twice as quickly!

The reason is that the array of small antennas can correlate flux from points separated by 1′, with all the advantages that implies, whereas the large antenna array must compare these points in a single-dish, point-by-point mode, and is therefore slower.

The smaller antennas have several additional advantages. Six meter antennas can be made to be essentially perfect using simple, cheap and proven technology (solid aluminum panels on a steel skeleton). This means that the beam efficiency will be higher. **Beam efficiency is as important as receiver temperature.** The smaller array does not have to point as accurately. The data from the smaller array does not have to be mosaiced - it can be reduced using AIPS as it now exists. The 30 element array produces 435 baselines at a time, compared with 15 baselines for the 6 element array. For a complex source, it will be necessary to move the antennas of the 6 element array to make an unambiguous map. This means that observers will have to return to the site several times over a period of months to make one map. Moving a 20-meter class antenna is much more difficult than moving a 6-meter class antenna. To move 20-meter antenna requires railroad tracks, and constrains the array to linear configurations. The 6-meter antennas can be moved with rubber-wheeled vehicles.

I think that the issue of receiver maintenance and replacement is a red herring. By the time the array is built, millimeter receivers will be almost indestructible, quantum-limited, and cheap. There will be little need to replace receivers.

Millimeter Array Memo 22 correctly points out that the array of large antennas is the more sensitive for sources smaller than the primary beam of those antennas; for sources which require mosaics of beams, however, an array of smaller telescopes will be better and cheaper. Most millimeter sources are extended— they are resolved even by small antennas. Consider the list of objects mentioned in the Barrett report: galaxies, clusters of galaxies, molecular clouds, HII regions. These types of objects are many arcminutes across, and will require extensive mosaics, even with 6-meter antennas. For these objects, an array of 20-meter antennas would be a severe handicap. Even single-dish millimeter-wave telescopes are rarely used at their full resolution, in the sense that almost all published millimeter maps are spatially undersampled by large factors, because the objects studied are much larger than the beams. An array whose field of view is only 20" or 30" is not sensitive to most millimeter wave objects.

The array element aperture size should be determined by the science to be done, by the choice of objects to be observed. Roughly speaking, arrays are fastest and most sensitive for objects comparable in size to the primary beam of an array element.

Yours truly,

Antony A. Stark

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Member of Technical Staff