MMA Project Book, Chapter 13.1

Imaging Requirements for the MMA

M.A. Holdaway
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H.A. Wootten
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Summary

Nonlinear mosaicing--the development of both techniques and algorithms--poses the most pressing set of imaging problems for the Millimeter Array.

Table 13.1 MMA Imaging Requirements.

Simulation	SDE/AIPS++ Software packages
Mosaicing	AIPS++ capability of mosmem routine in MIRIAD

Most development of imaging requirements useful for the MMA take place at BIMA, where the interferometer capabilities are most similar to the MMA.

Timescale:

- There are no principal goals to be achieved by the end of the MMA Design and Development (D&D) Phase.
- The imaging capability will be needed by the time the first few antennas are available in Chile, probably by the end of 2004.
- However, some capability of supporting holographic measurements during the test phase at the VLA site will be needed by 2001 Jun 1.

The primary imaging requirement for the MMA which is not well developed for use at the VLA, OVRO, BIMA and other interferometric imaging institutions is the development of nonlinear mosaicing techniques. These are currently fairly primitive within AIPS. Development is currently taking place using the MIRIAD package and BIMA data.

13.1 Simulation Capability

Full simulation capability: given a source structure, particular hour angle tracks (i.e., observing strategy), phase stability, opacity, (add other errors as required), what will the image sensitivity be like? How should one calibrate? What will the image quality be like? Simulation capability should be a tool to aid in the proposal process, and available to the astronomer checking the imaging as well.

Visibility weights should reflect the current noise level (i.e., reflect both changes in T_{sys} and opacity).

13.2 Mosaicing

Mosaicing combines multi field interferometric and total power data. The routines may be based on either maximum entropy (MEM) or CLEAN techniques; mosaics may be constructed using both linear and non-linear algorithms. At present no interferometer works well in total power modes; usually data from an antenna external to the array which is larger in size than the individual array elements provides total power data. When these data are combined, vexing decisions regarding matching the calibration of the flux scales of the two data sets must be faced. Even then, the options for mosaicing within existing software programs are restricted.

To provide the total power data, a set of antennas will synchronously sweep the heavens, providing data without stopping at fiducial sampling points. This is the On The Fly (OTF) observing mode. Data produced in the OTF mode will be combined with interferometer data to produce the dataset to be imaged. Currently, there is no seamless procedure to follow in combination of these data. Better OTF algorithms may be required, as errors in the total power imaging may limit the overall quality of mosaiced interferometer plus total power images.

Each of the methods of image restoration has advantages. CLEAN treats point sources quite well, as it approximates the image by a set of delta functions in one implementation. However, this does not often result in a pleasing portrayal of the millimeter/submillimeter sky, which consists of extended interconnected weak structures. MEM represents these structures well but has not produced results which are a quantitative as CLEAN. A combination of the two algorithms may result in more effective imaging techniques.

Mosaicing--the seamless integration of images taken at adjacent sky positions--is becoming more frequently used as interferometers gain sensitivity at higher frequencies, where their beamsizes are small compared to the scale of heavenly structure. Since enabling this technique within some software packages has required retrofits, the manipulation of multiple pointing data sets can be difficult. We expect this observing mode to be the norm at the MMA; there must be simple methods of manipulating complex multifield data sets.

For bright or rapidly changing objects, it may be desirable to do interferometry On The Fly. This can challenge the throughput rates of the data system; it has not been attempted on any interferometer yet. The integration times will be set by the minimum allowed by the correlator at the maximum dump rate for the desired number of channels. So, if the correlator is dumping with 0.1 s rates, the MMA will be slewing at about 3-4 beams per second.

When a fairly bright point source lies within an area to be imaged, small pointing excursions may be tracked over time by self-calibration. For determined antenna pointing offsets which have been determined, then a mean array offset may be measured in this way. This can, in turn, be applied to mosaic or other data to improve the imaging (Holdaway 1993 MMA Memo 95). Algorithms for application of pointing offsets to mosaicing data sets must be developed and tested.

Over time, each antenna will deform differently, owing to different solar heating, subtle structural differences or other factors. Since each antenna then departs from the idealized model primary beam, the quality of mosaic images will be affected. This problem becomes most severe at the highest frequency. It may be possible to develop self-calibration algorithms which solve for the varying antenna-to-antenna voltage patterns arising from these deformations. A final image would then be consistent with both the measured data and the deparltures of the individual antenna voltage patterns from the ideal. Such an algorithm would require a computationally intense routine, possibly unusably so.

References

Holdaway, M. 1993 MMA Memo 95.

mma@nrao.edu
