Antennas Working Group Meeting
March 13-14, 2008
San Francisco

Lynn Baker & Jim Cordes

Meeting Summary

The first meeting of the antennas working group was held at the Holiday Inn at San Francisco International Airport. It was hosted by the SETI Institute and chaired by Prof. William "Jack" Welch, principal investigator for the AWG. The 23 attendees were:

Peter Dewdney, Univ. Manchester / DRAO
Jim Cordes, Cornell Univ.
Lynn Baker, Cornell Univ.
Jack Welch, U.C. Berkeley
Matt Fleming, SETI Institute
Dave DeBoer, CSIRO / ASKAP
Willem Esterhuyse, MeerKAT Project, South Africa
L.J. du Toit, MeerKAT Project, South Africa
Venkat Lakshmanan, MeerKAT Project, South Africa
Dean Chalmers, DRAO
William Imbriale, JPL
German Cortes, Cornell Univ.
Roger Schultz, consultant
Sander Weinreb, Cal. Tech.
Larry d'Addario, JPL
Gary Hovey, DRAO
Jim Ulvestad, NRAO
Andrew Faulkner, Univ. Manchester
Joe Lazio, NRL
Roger Norrod, NRAO
Rick Fisher, NRAO
Jill Tartar, SETI
Rein Luik, consultant

There is a companion document to this one which lists all of the talks given at the meeting with a few line summary of each talk's content. This document, the abstract document and all the talks are available at:

http://skatdp.astro.cornell.edu/AWGMar2008.html

The presentations are available as power point slides and also as a flash recording which presents the audio synchronized with the power point slides.

Introduction

The meeting started with two talks by Peter Dewdney and Jim Cordes discussing the role of the AWG inside the US Technology Development Project (TDP) and the interaction between the AWG/TDP and the international SKA project. Lynn Baker then discussed the “matrix” of antenna parameters which must be specified to design an SKA reflector antenna.

World wide “pathfinder” projects

The largest set of presentations in the meeting were from four SKA “pathfinder” projects from around the world. These four projects and the presenters for each are:

Allen Telescope Array, ATA, Jack Welch, Matt Fleming
Australian SKA Pathfinder, ASKAP, Dave DeBoer
South African array, MeerKAT, Willem Esterhuyse, L.J. du Toit, Venkat Lakshmanan
Deep Space Network breadboard array, William Imbriale

These array projects can all be considered small prototypes for the SKA with each one having different emphases on the goals of the array and types of hardware utilized. All of these arrays are of modest size relative to the SKA, about 40 antennas at most.

In very brief summary. The ATA is an array at Hat Creek, CA consisting of 42 offset reflectors with single pixel feeds. The ATA-42 is mostly complete and is in the stage of final system integration. ASKAP is in the early design stages and will be located in a remote area of western Australia. Plans are for about 40 antennas which will be rotationally symmetric with a parallelatic rotator. The ASKAP antennas will be multibeamed using a phased array feed with digital beamforming. The prototype MeerKat antennas are rotationally symmetric with a single pixel feed. The final MeerKat design is still under consideration. The DSN breadboard array is a completed demonstrator project that investigated arrays of antennas for deep space communication. It successfully attained its demonstration goals and has since been disassembled and the antennas put to other uses.

All of these projects have substantial digital processing components that include beamforming, image processing, spectral analysis and other tasks. Successfully integrating the digital processing with the front end antennas is one of the most challenging parts of these projects.

Reflector fabrication techniques

There were two talks about fabrication techniques that might lead to low cost reflectors for use in the SKA. The first talk focused on composite fabrication and was delivered by Dean Chalmers from DRAO. The project is Composite Applications to Radio Telescopes, CART, which uses a vacuum infusion technique to mold cored composites with a single injection of resin. The first prototype antenna has been built and tested successfully and a second reflector with an improved design is planned.

The second talk on fabrication detailed the hydroforming process used create the 6 meter single shell antennas used in the ATA and was delivered by Matt Fleming. Detailed costs of the mold and process were presented along with cost estimates of extending the technology to 12 meter antennas.

Broadband receiver & feed development

Sandy Weinreb from Cal Tech delivered a talk covering several aspects of low noise, broadband receivers under development at Cal Tech. He also reviewed the status of broadband, single pixel feeds be developed at Cal Tech and other institutions. There are several new transistors which offer excellent noise and bandwidth performance. These have been built into single ended amplifiers and differential input amplifiers are under development. The differential input amplifiers are being designed to match the input characteristics of broadband feeds which all have a balanced type input impedance of a few hundred ohms. All of the dual polarization, broadband feeds have a common need for a dual twin lead transmission line interface between the feed and amplifier and such a device is under development.

Initial reflector optics designs

German Cortes of Cornell reported on the development and characterization of a wide band feed and its use in symmetric and offset reflector designs. Optimization and analysis of several example antennas was presented including calculations of far sidelobe patterns. A plan for further work on reflector optics was shown.

Roger Schultz, consultant, presented a schematic design of a 12 meter offset antenna developed by extending the size of the ATA 6 meter antennas.

Cost modeling of large antennas

Larry D'Addario of JPL presented a critique of previous models of antenna cost and then developed an improved model. Several caveats about the accuracy of cost modeling were emphasized.

Larry also presented a brief review of the polarization characterization of radio telescopes.

Discussion and conclusions

The most important discussion item was the lack of detailed antenna performance specifications to guide the design of the SKA antennas. The science requirements refer to the performance of the entire array. The requirements placed on the individual antennas are derived from the array performance via analysis of the digital signal processing used to form images and array beams. This analysis will be performed by the calibration and processing group (CPG) but that work has just begun and will not be completed for some time.

The partial solution to this problem is to study generic designs, especially subsystems like mounts and drives. A study of reflector fabrication methods with emphasis on low cost mass manufacture was suggested, specifically hydroforming of shell reflectors.

It was generally concluded that the TDP should strive to produce a fully operational prototype antenna at project end. Such a prototype might well be sited at the VLA.

Action Items

1. Define “strawman” antennas for initial studies. These would include both symmetric and offset examples. The optics would be targeted toward the patterns of the broadband, single pixel feeds presently being developed.

2. Develop a preliminary plan and timeline for study of fabrication techniques and analysis of “strawman” antennas, including thermal/solar, gravitational and wind effects.

3. Identify an antenna test range for testing of candidate broadband feeds. Such a range needs to cover .5 to 10 GHz with sufficient accuracy, be reasonably accessible and not too costly.

4. Develop a set of feed measurement metrics and methods to be consistently applied to all candidate feeds, enabling accurate comparisons. This includes patterns, polarization, input impedance, and noise temperature when combined with a receiver.

5. Develop analogous metrics for measurement of reflector antennas on the sky.

6. Identify explicit collaboration with South African MeerKAT project on feed selection and reflector optics design.