IN TOUCH WITH MWA

Murchison Widefield Array

Issue 1, November 2007 www.haystack.mit.edu/ast/arrays/MWA

INAUGURAL ISSUE OF MWA NEWSLETER

This is the first issue of the MWA newsletter, to be published 6 times a year from the Project Office. The objective of the newsletter is to share knowledge among our geographically far-flung project members about progress and plans in various areas of MWA development. It will also highlight progress and plans to sponsors, advisors and colleagues associated with the MWA, across the globe. The newsletter will serve as a central, authoritative and widely accessible source of information about the project.

While the newsletter is edited by Preethi Pratap (MIT/Haystack), and issued by the Project Office, we strongly encourage submissions of material for inclusion, particularly if it highlights a topic of broad or timely interest. In this issue, one focus is the EoR science area, with a glimpse of future possibilities for MWA style technology, by Avi Loeb (Harvard). The issue is also marked by accounts of the first major project activities at the Boolardy site, an exciting time for all who have worked hard for this milestone.

As we enter 2008, MWA field activities, and then major construction activities will quickly ramp up. As progress is made and data of various kinds starts to flow, the broad MWA community will be kept informed and involved through this and other forums.

EXPEDITION REPORT – X1: Tile Installation

As of this writing, the X1 expedition team is nearing the end of its 8-day presence on-site. The primary goal of the expedition has been to install 32 antenna tiles as the first major step toward a completed 32-tile engineering testbed system. The X1 team is led by Brian Corey (MIT Haystack), and includes Mark Derome (MIT Haystack), Steve and Bob Burns (Burns Industries, NH, our antenna manufacturer), Chris Williams (MIT Kavli), Anish Roshi and Somashekar R. (RRI), Jamie Stevens (U. Tasmania), Merv Lynch and David Herne (Curtin). A CSIRO representative has also been on-site (Dave deBoer, later relieved by Ant Schinckel), along with an indigenous monitor, for a total of 12 individuals.

This team has made terrific progress through a lot of hard work, building out the 32 tiles quickly, efficiently, and with no significant problems, despite ferocious summertime heat and a plague of flies. The photo shows the first assembled MWA tile with Chris making some adjustments at the ground screen, Mark, Bob and David.

The recently installed, CSIRO-provided infrastructure (see below), offering shelter and a sensible working environment, has been an essential ingredient toward this first major MWA milestone in the field. This X1 experience illustrates the path to a cost-effective deployment of the full 512-tile system, of which tile installation is perhaps the most labour-intensive part. The team has also conducted performance tests of the antenna tiles. Results from these tests, and those from upcoming expeditions, will be reported in the next newsletter.

An additional activity for the X1 team, and for David Herne (Curtin) in particular, was installation of the MWA GPS units (courtesy of AFRL) at Boolardy in order to gather data on the ionosphere. These systems will be used for absolute calibration of the total electron content of the ionosphere above the MWA, which is critical for multiple science applications. Data have been gathered and will be analyzed in coming weeks.

Congratulations and thanks to the X1 team for a job well done!

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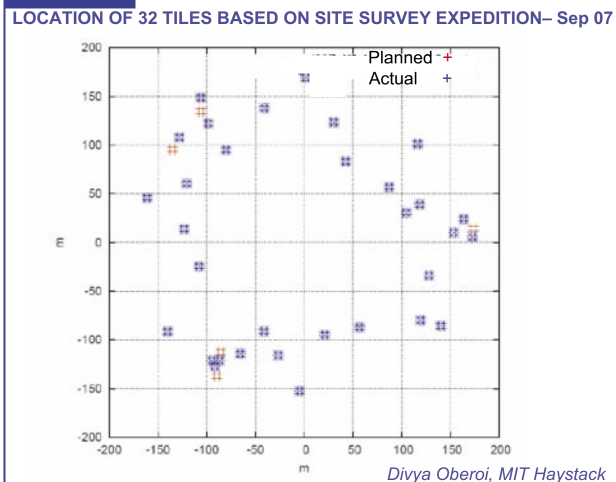
Progress Report - Plans

32-TILE SYSTEM – General Progress Report and Plans

The X1 expedition is one in a series that is envisioned to culminate in a system capable of delivering real-time data for all 496 baselines from all 32 antenna tiles. This system will be a powerful testbed for a wide variety of hardware and software engineering tests, and will also deliver a significant opportunity for early science.



Results of X0 site survey

Currently, it is hoped that the system can reach this capability milestone by March 2008. Many key array hardware components are under rapid development, with prototype units to be delivered in the December-January timeframe. The first analog beamformer units will appear from Haystack in early December, along with certain elements of the receiver analog and digital signal path from RRI and ANU. A fully integrated node receiver is targeted for January, at which time all 32 beamformers should be ready. Correlator hardware sufficient to generate 496 baselines in real time is under development, with March as an aggressive target for field-readiness. At a minimum, a data capture capability will be available in that timeframe, facilitating software correlation and establishing the basic 32T testbed functionality.

In summary, the various expeditions (X) for the 32-Tile system with projected future dates are as follows:

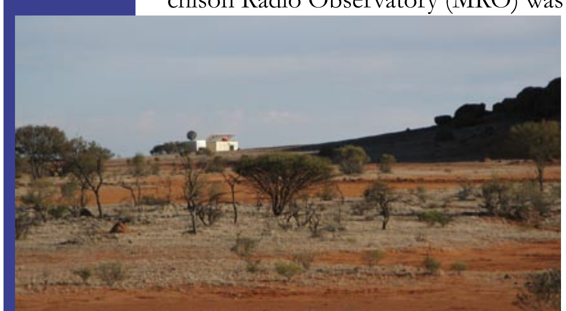
X0: Sept 07: Site survey for 32 tiles
X1: Nov 07: Installation of 32 tiles and basic performance checks
X2: Dec 07: Signal path tests through receiver and beamformer
X3: Jan 08: Installation of complete node receiver and 32 beamformers
X4: Mar 08: Installation of nodes 2 to 4 and creation of full 32-tile imaging data sets.

For a report on X0, the site survey expedition, please see the November 2007 issue of the Australian SKA newsletter (no. 15), which contains an article by Divya Oberoi (MIT/Haystack) and some interesting photos. (http://www.atnf.csiro.au/news/auska-newsletter/)

The surveyed locations of the 32-tiles resulting from this expedition are shown in Figure x, and are very close to those planned through the simulation.

SITE INFRASTRUCTURE

A temporary license to carry out low impact radio astronomy activities at the Boolardy Station within the Murchison Radio Observatory (MRO) was granted to CSIRO by the State of Western Australia on October 5, 2007. This has allowed the MWA project to begin deployment of its systems in a phased process under the supervision of CSIRO, starting with the installation of the 32 tiles. The MWA Project Office is working with CSIRO to develop a formal memorandum of agreement and a site implementation plan for the MWA covering both the near-term deployment of the 32-tile system and the longer-term deployment of the entire 512-tile array according to the established schedule for the project.



In support of the radio astronomy activities at the MRO, CSIRO/ATNF has begun to install infrastructure components that will facilitate the MWA array deployment activities. The initial infrastructure includes two equipment huts (see photo), an office trailer, electrical supply, and a satellite network link. All these have been used effectively during the first MWA expedition in early November and are gratefully appreciated by the MWA team. Additional photos can be found in the AU SKA newsletter referenced above. Upgrade of the accommodations at the Boolardy Station is in progress.

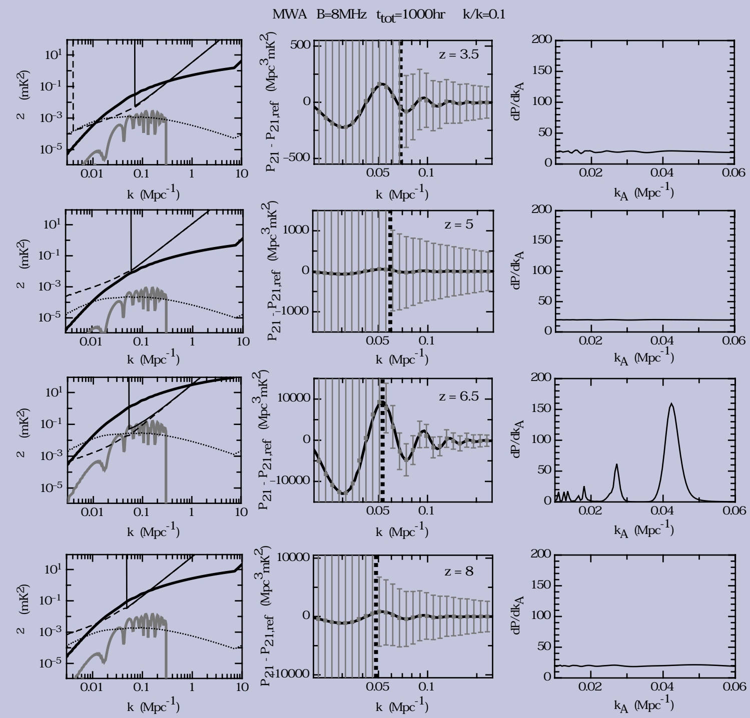
HOT SCIENCE TOPIC

21cm Emission After Reionization and the Detection of Baryonic Acoustic Oscillations

— Avi Loeb, Harvard CfA

The fluctuations in the emission of redshifted 21cm photons from neutral inter-galactic hydrogen will provide an unprecedented probe of the reionization era. Conventional wisdom assumes that this 21cm signal disappears as soon as reionization is complete, when little atomic hydrogen is left through most of the volume of the inter-galactic medium (IGM). However observations of damped Ly-alpha absorbers indicate that the fraction of hydrogen in its neutral form is significant by mass at all redshifts. In a recent paper (MNRAS, in press; arXiv:0708.3392), Stuart Wyithe (U. Melbourne) & Avi Loeb (Harvard) used a physically-motivated model to show that residual neutral gas, confined to dense regions in the IGM with a high recombination rate, will generate a significant post-reionization 21cm signal. They show that the power-spectrum of fluctuations in this signal will be detectable by the first generation of low-frequency observatories (such as MWA) at a signal-to-noise that is comparable to that achievable in observations of the reionization era.

This has important political implications, since it implies that MWA could obtain interesting scientific results even if the IGM was reionized before its redshift window (3.5<z<15). In a follow-up paper, Wyithe, Loeb, & Geil showed that a dedicated future extension of MWA will be able to probe the scale of the baryonic acoustic oscillations (BAOs) at low-redshifts with a comparable sensitivity (better than a few percent) to that achievable by the popular (and much more expensive) "dark energy missions" which survey galaxies or search for supernovae. The study of 21cm fluctuations has the potential to constrain the contribution of the vacuum to the cosmic energy budget beginning at a few hundreds of millions of years after the big bang and ending up at the present time.



The power spectrum of 21cm fluctuations and measurement of the baryonic acoustic oscillations (from Wyithe, Loeb, & Geil 2007). Results are shown at four redshifts, z=3.5, 5, 6.5 and 8, and assume a low-frequency array with the specifications of the MWA, 1000hr of integration on a single field and foreground removal within B=8MHz of band-pass. Left panels: The power spectrum of 21cm fluctuations (thick solid lines). The absolute value of the component of the 21cm power spectrum due to the baryonic acoustic oscillations is also plotted at wavenumbers k<0.3 Mpc^{-1} (heavy grey lines). Also shown for comparison are estimates of the noise. In each case we plot the sample variance (dotted lines) and thermal noise (dashed lines) components of the uncertainty within k-space bins of size k/10. The combined uncertainty including the minimum k cutoff due to foreground subtraction, is also shown as the thin solid lines. Central panels: The power spectra with the representative smooth power spectrum subtracted. The points with error bars show the accuracy attainable within a bin of width 0.1k. The vertical dotted line is the wave number corresponding to the band-pass, below which the error bars are very large. Note that the vertical scale is different at each redshift and has been chosen to best illustrate the magnitude of the uncertainty relative to the amplitude of the BAOs. Right panels: The probability distributions for the recovered acoustic wave number at each redshift.

MWA PROJECT MEETING

The next semiannual MWA project meeting will be held on 4-7 December 2007, and is hosted by the University of Melbourne. The meeting location is Kona, Hawaii. See details at http://astro.ph.unimelb.edu.au/mwa/hawaii/index.html.

The purpose of the meeting is to review progress since the June 2007 meeting held at MIT and Haystack, and to plan the next set of project activities. The general agenda is as follows:

4 Dec: Project Overview
- Site Infrastructure and expedition reports
- Core system reports
- Field Installation plans

5 Dec: Science Council meeting
- Recent science topics of interest
- Transient Collaboration
- EOR Collaboration
- SHI Review

6 Dec: 32-T plans and tests
- Operations, funding and the future – panel discussion
- Breakout sessions

7 Dec: Issues arising
- Wrap-up session, action items, meeting report
- Board meeting

8 Dec: Trip to Mauna Kea (optional)

INTERPLANETARY SCINTILLATION (IPS) COMMON FORMAT

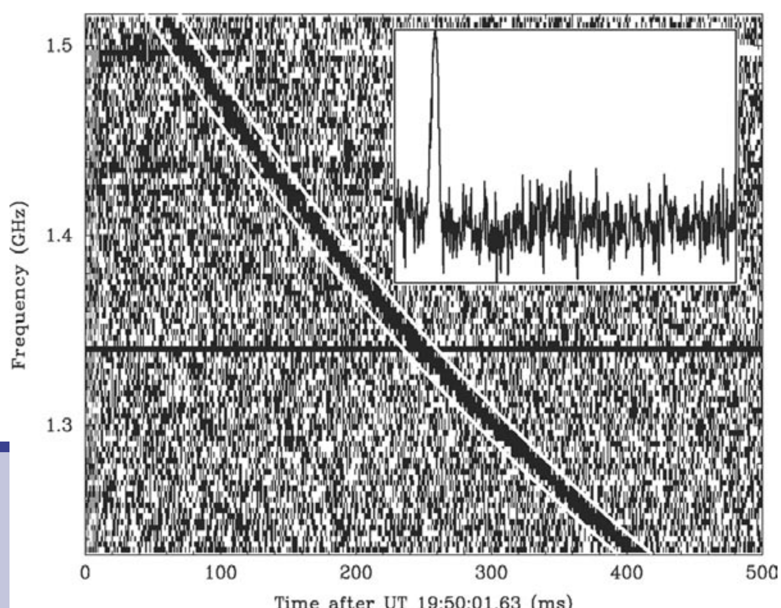
Some effort has been recently concentrated on preparing a proposed format for the MWA IPS data. Establishment of a common IPS data format was among the subjects discussed at a special workshop hosted on 30-31 October 2007 by the Solar Terrestrial Environment Laboratory (STEL) in Toyokawa, Japan, with participation by all current and planned IPS observatories and data analysis centers. The motivation behind a common data format was two fold. First, to ensure a common content and format so that observations from various facilities can be analyzed by the IPS groups using different techniques and second, to make it easier for the wider solar and heliospheric physics community to make use of IPS data by providing them science ready data while shielding them from the specifics of instruments. On one hand these motivations require the data set to include comparatively unprocessed data to provide the freedom to experienced IPS users to analyze it in a manner of their choice, and on the other hand it must also include some high level data products which can directly be ingested by the wider community.

To meet these diverse needs, the IPS data format needs to be hierarchical in nature and must include data at three different levels of processing - the flux calibrated time series data, the IPS observables of power spectrum or cross-correlation function constructed from this time series, which usually form the inputs to the IPS modeling methods, and also the results of fitting some standard solar wind models to these observations. This proposal was well received by the IPS community and a tentative agreement has been reached at the workshop on the contents of the data files to be shared. Work is now being initiated to identify the details of the format. A report on these activities will be presented at the December MWA project meeting by Divya Oberoi, who participated in the IPS workshop and is responsible for developing a detailed proposal for the common IPS format.

TRANSIENT SCIENCE

– Recent article by Lorimer et al

We bring to your attention the recent discovery of an extragalactic transient source by Lorimer et al. (2007, Science, 318, 777) which was made in a reanalysis of archival data from the Parkes 1.4 GHz multibeam survey (right). This burst was so intense it caused an overload of the detector. The MWA offers many such opportunities for discovery with its widefield and broad spectrum coverage. An overview of the possibilities can be found in Bower (2007, Science, 318, 759).



Frequency evolution and integrated pulse shape of the radio burst located 3° from the Small Magellanic Cloud. The survey data, collected on 24 August 2001, are shown here as a two-dimensional "waterfall plot" of intensity as a function of radio frequency versus time. The dispersion is clearly seen as a quadratic sweep across the frequency band, with broadening toward lower frequencies. From a measurement of the pulse delay across the receiver band, standard pulsar timing techniques provide a determination of the DM to be 375 ± 1 cm–3 pc. The two white lines separated by 15 ms that bound the pulse show the expected behavior for the cold-plasma dispersion law assuming a DM of 375 cm–3 pc. The horizontal line at ~1.34 GHz is an artifact in the data caused by a malfunctioning frequency channel.(from Lorimer et al. 2007).

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