DEVELOPMENTS IN NORTH AMERICA AT LONGER WAVELENGTHS

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ABSTRACT

The instruments currently operating or planned for centimeter and longer wavelengths in Canada and the United States are briefly reviewed. References to on-line documents are provided for readers wanting more detailed information about these observatories.

INTRODUCTON

A number of observatories and projects are currently active in providing radio astronomical observing capabilities at centimeter and longer wavelengths in Canada and the United States. These activities are briefly reviewed for each observatory or project, listed in alphabetical order. Where available, references to on-line documents are provided for those readers interested in more detail concerning the current status of these activities .

ALLEN TELESCOPE ARRAY PROJECT (ATA)

The ATA [1] is a joint project between the SETI Institute and the University of California at Berkeley Radio Astronomy Lab (RAL). The ATA will consist of approximately three hundred and fifty 6.1-meter diameter offset Gregorian dishes arrayed on baselines from 11 to 700 m at the Hat Creek Radio Observatory. The radio frequency (RF) range accessible for observations will be 0.5- 11.2 GHz. Planned outputs from the array include up to 16 phased-array beams each with a bandwidth of 100 MHz and visibility functions from a 350 station correlator. A number of innovative designs are being used to keep the cost significantly below the cost of previous arrays of this size. Some of the new technologies include: antenna surfaces fabricated in a single piece by hydroforming, a single feed and cryogenically cooled receiver covering the full RF band, return of the full RF band to the central building using an analog fiber-optic link. All equipment is currently being prototyped with a goal of beginning construction of the full array in 2003.

HAYSTACK OBSERVATORY

Haystack has a number of new radio astronomy projects under way. An array [2] dedicated to the detection of deuterium is now being prototyped with construction planned to begin in 2003. The array will cover the frequency range 322-329 MHz and will consist of 32 stations, with each station consisting of a 5x5 dipole array equipped with dual-polarization digital receivers. The total collecting area is projected to be 384 m^2. Another project is the development of the Mark 5 VLBI data recording system [3] based on low cost magnetic discs. The system will support data rates of at least 1 Gbps with 24-hour unattended operation. Also in the area of VLBI, a project known as e-VLBI [4] will demonstrate real-time VLBI using an optical fiber link between telescopes at Westford, MA and Goddard Space Flight Center, MD. Haystack is also a partner in the Low Frequency Array Project (LOFAR) – see the LOFAR entry below. Haystack is active in radio astronomy education, both through the use of the Haystack 37 m antenna and through the development of a small radio telescope (SRT) [5] of which 70 units have now been deployed at various US and international institutions.

DOMINION RADIO ASTROPHYSICAL OBSERVATORY (DRAO)

The synthesis telescope [6], consisting of seven 9 m diameter antennas operating simultaneously at 408 and 1420 MHz, is spending the majority of its time on the Canadian Galactic Plane Survey. This survey [7] is a project to map 60 degrees of the Galactic plane at numerous wavelengths with a uniform sensitivity. The Large Adaptive Reflector (LAR) project [8] has the goal of building a 200 m diameter reflector operating in the frequency range 0.25-22 GHz with the feeds and receivers suspended from a tethered aerostat 500 m above the reflector. A one-third scale model of the aerostat is now flying and experiments are underway to prove the airborne platform concept. DRAO is also designing and building the correlator [9] for the EVLA Project (see the EVLA description below).

JET PROPULSION LABORATORY (JPL)

JPL has 70 m and 34 m diameter antennas at its three Deep Space Network Sites in Australia, California and Spain and accepts proposals for radio astronomical use of these facilities [10]. Receivers available on various, but not all, antennas include 1.6, 2.3, 8.4, 12, 18-26, 32 and 40-50 GHz [11]. Additionally, a receiver for 86 GHz is in development. The Goldstone Solar System Radar system [12] provides transmitters on the 70 m antenna for 2.3 and 8.6 GHz for radar studies of Solar System planets, moons, asteroids, comets and orbital debris. Most radar observing is monostatic but bistatic observations with the VLA and GBT have also been made. JPL has an active radio astronomy science education program centered around the Goldstone Apple Valley Radio Telescope (GAVRT) [13].

LOW FREQUENCY ARRAY PROJECT (LOFAR)

LOFAR [14] is a joint project of ASTRON in the Netherlands and the Naval Research Laboratory (NRL) and Haystack Observatory in the USA.The frequency range for the instrument is expected to be 10-240 MHz divided into a low range of 10-90 MHz using active dipoles and a high range of 110 to 240 MHz using phased 16-dipole arrays. The total number of receptors is approximately 13000 (low) and 200,000 (high) allocated between 80 and 220 stations. Design of the array is planned to be completed in 2004 with construction starting after that. NRL is working on low band antennas, receivers, and calibration issues and Haystack is working on high band antenna design, digital system design, and overall performance simulations.

NATIONAL ASTRONOMY AND IONOSPHERIC CENTER (NAIC)

The surface of the 300 m Arecibo telescope [15] has been measured using photogrammetry and a first round of adjustment of the 38,778 panels has produced a surface accuracy of better than 2 mm, allowing operation at frequencies as high as X-band. Representative values [16] for telescope sensitivity are 10, 7 and >2 K/Jy at 1.4, 5 and 9 GHz respectively. Work to improve the surface accuracy further will continue in 2002 as will design and installation of a noise reduction skirt around the edge of the tertiary reflector. Work is continuing on a 7-pixel dual polarization receiver for 1.225-1.525 GHz with a goal of installation in 2004. A new pulsar processor, the Wideband Arecibo Pulsar Processor (WAPP) [17], provides up to 100 MHz bandwidth and there is a goal to soon have 4 WAPPs. A significant new VLBI capability now available for use is a VLBA4 recording system which is compatible with VLBA, EVN and Global network observations [18]. The upgraded S-band radar system has produced dramatic new results on Near-Earth Asteroids, planetary surfaces, Saturn's rings and Titan [19].

NATIONAL RADIO ASTRONOMY OBSERVATORY (NRAO)

The 100 m diameter, unblocked-aperture Greenbank Telescope [GBT] [20] is now being commissioned and is also being used for early scientific observations. Commissioning to 15 GHz without the use of the active surface has been achieved with the expected aperture efficiencies. First tests of the active surface operating in open-loop mode have been made and the expected improvements in surface accuracy and elevation dependent gain curve have been observed at 20 GHz. First 20 GHz science is expected in April, 2002 and the goal for operation at 40-50 GHz is the end of 2002.

The Very Large Array (VLA) [21] now has a fiber optic link to the nearest Very Long Baseline Array (VLBA) antenna at Pie Town. When the VLA is in the A configuration the Pie Town antenna can be included with 26 VLA antennas to provide a factor of 2 increase in the angular resolution of the VLA [22]. A program of installing improved receivers for the bands 20-26 GHz and 40-50 GHz is continuing [23] and should be complete in 2003. A major project to upgrade the VLA, called the Expanded VLA (EVLA) Project, has now begun [24] with goals of providing continuous frequency coverage in the range 1-50 Ghz and up to 16 GHz of correlation bandwidth per antenna.

Receivers for 80-96 GHz are continuing to be installed on the VLBA [25] and a system for measuring and improving the surface accuracy of the primary and secondary reflectors is in development. A software pipeline which significantly simplifies the processing of VLBA data has been put into operation.

The AIPS++ Project [26] is continuing in its scientific integration phase, including intensive testing of the software package by NRAO staff members. A large part of this work has been in support of the commissioning and early scientific operations of the GBT. A new software project, the End-to-End Project (e2e) [27] , has begun with a goal of providing uniform end-to-end processing for observations from all NRAO telescopes.

OWENS VALLEY RADIO OBSERVATORY

The centimeter wavelength instruments in operation at the Caltech Owens Valley Radio Observatory [28] include a 5.5 m and a 40 m diameter telescope used for Cosmic Microwave Background observations. An array of two 27 m antennas with three 2 m diameter antennas is used for solar studies over the frequency range 1-18 GHz.

SQUARE KILOMETER ARRAY PROJECT (SKA)

The SKA [29] is an international project with a goal of building a radio telescope with one square kilometer of collecting area operating in the approximate frequency range 0.15-20 GHz. Studies are being done in Australia, Canada, China, India, Europe and the United States. The Canadian SKA work is centered at DRAO and is based on using antennas similar to the LAR (see DRAO entry above). The US SKA work is organized by the US SKA Consortium [30], a consortium of ten US institutions. The consortium is working on a concept for the SKA that is based on a large number of small (6-12 m diameter) reflector antennas, as is currently being prototyped by the ATA Project (see ATA entry above).

UNIVERSITY OF MICHIGAN RADIO ASTRONOMY OBSERVATORY (UMRAO)

The UMRAO [31] operates a 26 m diameter telescope equipped for observations at 4.8, 8.0, and 14.5 GHz. The telescope is used primarily for long term monitoring of the total flux density and linear polarization of radio sources. A data base of results is available on the web site.

ACKNOWLEGEMENTS

The National Radio Astronomy Observatory is a facility of the (U.S.) National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

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