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mission control

Super bowl

Following the completion of the largest single-dish radio telescope ever built, the real work may now begin, explain **Rendong Nan** and **Haiyan Zhang**.

The Five-hundred-meter Aperture Spherical radio Telescope (FAST) is the result of a Chinese megascience project to build the largest single-dish radio telescope in the world. The receiving area of FAST is equivalent to about 30 football fields, and its large bowl could provide 0.4 bottle of wine for each person in the world (pictured, bottom). Compared with the Arecibo 305 m radio telescope, FAST has three outstanding aspects: its site is a deep and round karst depression named Dawodang in Guizhou province (pictured, top), it uses an active reflector to correct spherical aberration, and it has a lightweight feed cabin driven by six cables and a servomechanism plus a parallel robot for closed-loop precision control.

The exquisite sensitivity due to its size is ideal for large-scale surveys. FAST will enable astronomers to get a jumpstart on many science goals — for example, the neutral hydrogen line survey of distant galaxies out to very large redshifts would provide significant information on the origin and evolution of the Universe.

Even higher sensitivity can be achieved by joining FAST with the international Very Long Baseline Interferometry network. This system may be able to resolve the fine structures of weak thermal sources, to get a close-up on the origin and evolution of stellar sources, and even to directly image the radio-loud extrasolar systems.

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Construction progress

The story of FAST dates back to 1994, with the submission of the initial proposal. It was 2007 before the funding proposal gained approval. In 2011, the building phase of the project commenced. The girder ring of FAST to support the cable-net of reflectors was fully formed in September 2014 and, half a year later, the installation of the cable-net itself followed suit. On 3 July 2016, the last of the 4,600 reflector elements was successfully placed.

Meanwhile, the feed support system including six support towers and feed cabin housing the secondary adjustment system were constructed. The hardware and software for the measurement and control systems has been developed to ensure the high precision of astronomical observations. In addition, seven sets of receivers were designed and constructed based on international cooperation, such as the construction of the 19-beam receiver for FAST by the Commonwealth Scientific and Industrial Research Organisation in Australia. In order to protect the radio environment of the FAST site, the local government established a radio quiet zone with a radius of 30 km in 2013. The main structure of the telescope was completed after five and a half years of construction.

Early science and outlook

The key science goals of FAST involve the 21 cm neutral hydrogen hyperfine structure line (H I), pulsar emission, the radio continuum, recombination lines and molecular spectral lines — including masers — based on observables between the 70 MHz and 3 GHz bands. In particular, three projects of the early science programme are: the H I survey, a pulsar search in nearby galaxies and globular clusters (including M31, which is out of Arecibo coverage), and the OH megamaser search and spectral line survey in Orion.

Following the construction of FAST, ongoing adjustments of the telescope are improving the ability to observe with high precision. However, the complexity and the innovative nature of the FAST systems pose many challenges. The early science goals were proposed and prepared during the telescope construction period. Within the technical constraints of the early science operations there will still be some opportunities for focused programmes of significant impact at wavelengths longer than the L-band. Observations in drift–scan mode have been proposed to avoid the complex scan patterns and fast driving/switching of the telescope.

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A single-pixel receiver covering the 270–1,620 MHz band has been designed and mounted at the feed cabin, providing a platform for observations during the early stages of operation. Since the FAST inauguration in September, we have been testing this wideband receiver. In the near future, we expect FAST to observe routinely and to provide a significant opportunity for extraordinary discoveries in the Universe. ❐

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