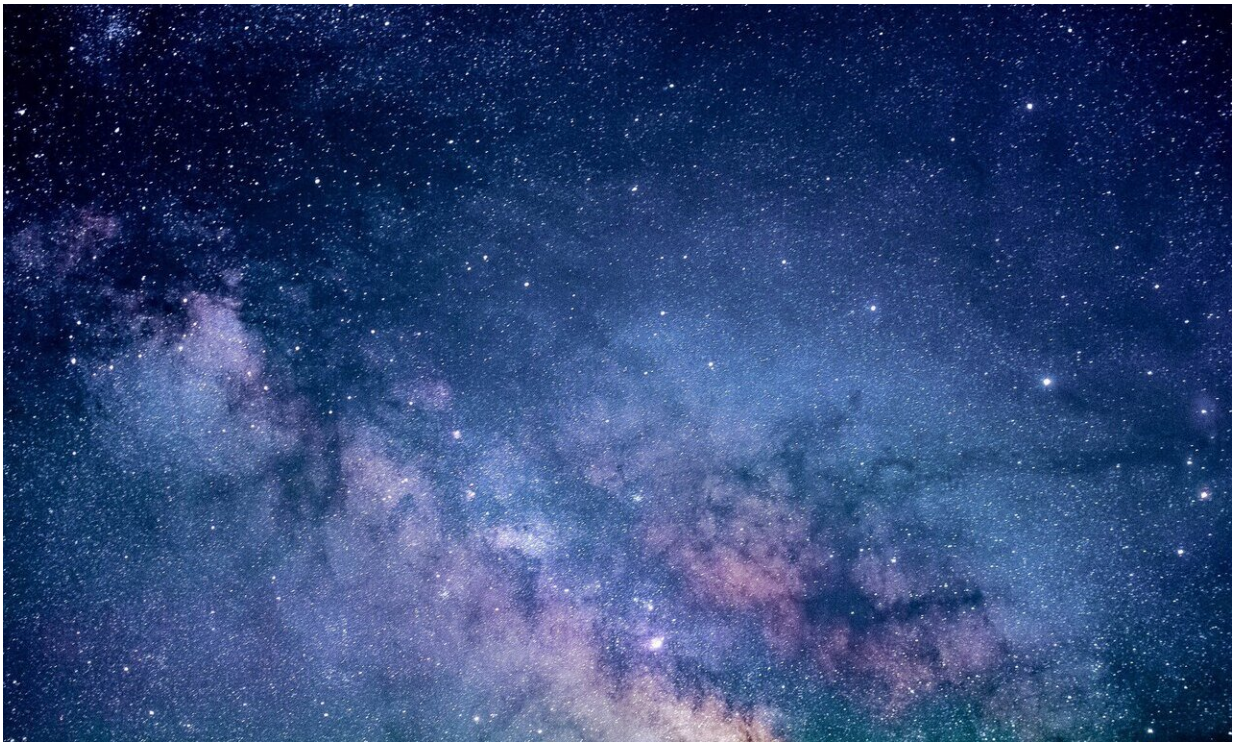
China Sky Eye, the world's largest single-dish radio telescope, is now fully operational

September 9 2019



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China's Five-hundred-meter Aperture Spherical Radio Telescope, known as FAST, is the world's most sensitive listening device. The single-dish radio telescope is made of 4,450 individual panels that scan the sky, detecting the universe's whispers and shouts. It's cradled in a natural Earth depression the size of 30 soccer fields. It has more than twice the

collecting area of the world's previous largest radio telescope, the 305-meter dish in Arecibo, Puerto Rico. With construction completed in 2016, FAST has undergone rigorous testing and has one more hurdle before it's considered fully operational.

At the end of September, the $171 million USD (1.2 billion CNY) project will undergo the final review process in China, called the National Construction Acceptance.

"We fully expect a successful review at the national level, and then we'll transition from being a construction project to a full facility," said Li Di, FAST's chief scientist and leader of the radio astronomy division of the National Astronomical Observatories of Chinese Academy of Sciences (NAOC). NAOC oversees FAST.

"Once we pass this review, FAST becomes an accepted telescope for exploring the Universe," said Jiang Peng, FAST's chief engineer and deputy director of FAST Operation and Development Center, NAOC. "Fast has been open to Chinese astronomers since April 2019. After the National Construction Acceptance, it will be open to astronomers across the world."

For the review to be successful, FAST must meet the specifications initially laid out in the proposed design in 2008, such as the telescope's sensitivity and performance. NAOC ran an internal review earlier this year, demonstrating that the telescope is as—if not more—sensitive than planned.

The construction of FAST, while solely funded by the Chinese government, involved collaboration with international organizations, including Australia's Commonwealth Scientific and Industrial Research Organization, but exactly who in the international community will be able to use FAST—and to what extent—is still to be decided. While both

Li and Jiang stressed the importance of international collaboration (they have both conducted research using data from radio telescopes in Australia and in Puerto Rico), the decision lies with the Chinese government.

"Our hope for FAST is an open-sky policy, with the goal of advancing the work of humanity," Li said.

That work could include the detection of pulsars, for example. When a giant star collapses in on itself, it forms a dense neutron star that rotates, flashing a beam of intense radiation every so often. The beam is called a pulsar, and it can't be visually observed. However, because that flash is a radio signal, scientists can listen for it using a radio telescope like FAST. Once they detect a pulsar, they can use it to identify and measure the behavior of other physical phenomena, such as gravitational waves.

In the few years FAST has been scientifically operational, they've already made significant scientific headway, including the discovery of 130 new pulsar candidates, 93 of which were confirmed with other radio telescopes. By comparison, the Arecibo Observatory in Puerto Rico has published the discovery of 200 pulsars since 1968.

"Our goal is to catch up," Li said. "And eventually have hundreds of new discoveries every year."

Beyond pulsars, the researchers are looking for Fast Radio Bursts (FRBs)—the unexplained yet extremely energetic radio signals that are much louder than pulsars despite being much further away. On August 29, FAST detected more than a few dozen bursts from FRB 121102, the first repeating FRB source ever discovered. This source has been constantly monitored by major telescopes around the world since its discovery in 2012. FAST however, was the first telescope to detect so many bursts in such a short amount of time, attesting to its sensitivity

and processing power. The FAST science team is now analyzing the data, which may help elucidate the FRB's origin.

They're also looking for hydrogen, the most abundant—and suspected oldest—element in the universe.

"We're going to discover curious emissions," Jiang said. "These observations could improve our understanding of high-energy physics, star evolution, and galaxy evolution."

They've also organized two major surveys that will take about five years to scan the sky, with another ten years dedicated to analyzing the information collected.

"These programs are straight forward, and account for the research we can plan," Li said. "But there's always known unknowns and unknown unknowns that require creativity in planning."

The surveys will take up about 50% of FAST's scanning time, during which the researchers will also look for exoplanets with a magnetic field—a crucial component for supporting life, according to Li.

Now that FAST is approaching the final review stage, Li said he is relieved.

"I don't have any anxiety about it," Li said. "FAST has exceeded my own expectations. I'm very grateful to our primary driver and founder, Dr. Nan Rendong, and the excellent, hard-working engineering team. We've already collected more than enough data for me to work on for the rest of my career. There's so much we can study."

Jiang said he is excited, but also feels a responsibility to make FAST even better. In the first submission process of individual researchers

interested in pursuing research projects, FAST received 133 proposals with more than 500 associate scientists.

"These individuals also bring with them students and junior scientists," Jiang said. "They could build their careers using FAST data. We hope that more and more scientists can make use of FAST to produce excellent scientific results in the future, making our efforts even more meaningful."

Both Li and Jiang agree that FAST is a product of exponential scientific growth in China since 2000.

"We're a beneficiary of vast advancement of infrastructure in both science and technology," Li said. "We are also a contributor. We hope to continue to contribute by making FAST not only a successful construction project, but also something that can be a global landmark in radio astronomy."

Provided by Chinese Academy of Sciences