FAST Reveals Mystery of Fast Radio Bursts from the Universe

In the vast universe, some extremely strong radio waves occasionally blink, with durations of only milliseconds. Such fast radio bursts were discovered by astronomers in 2007. Puzzling questions arise: Who sent them? What information is conveyed by these radio bursts?

The Five-hundred-meter Aperture Spherical Radio Telescope (FAST) has revealed some mystery of the fast radio bursts (FRBs), according to a study published in *Nature* on Oct. 28.

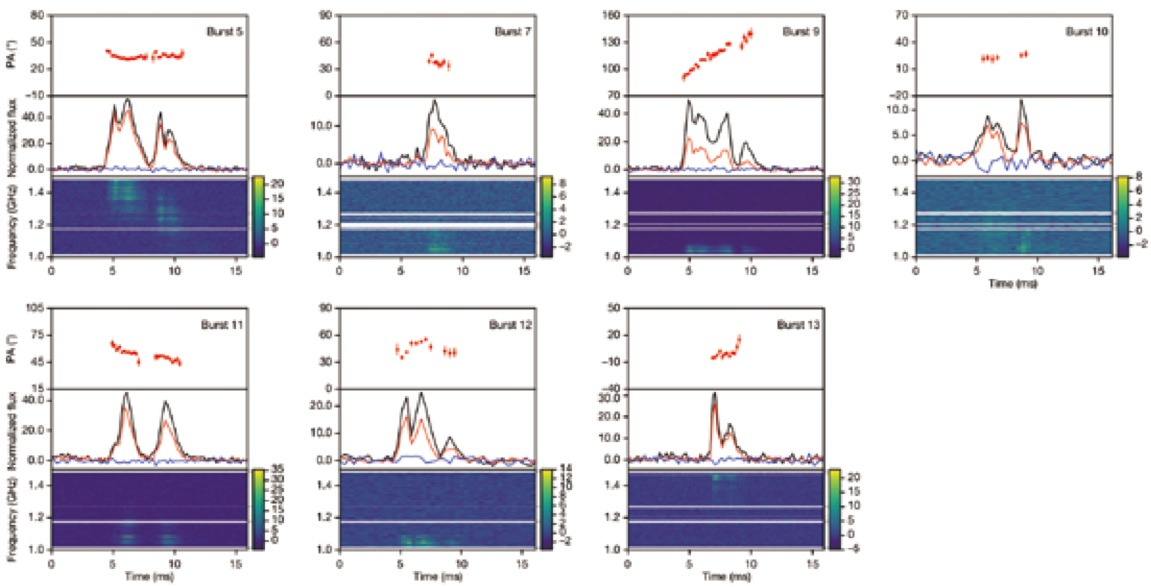
More than 30 burst sources have been found until last year. These bursts randomly emerge in the sky, which implies that most of them are not from the Milky Way but outside.

In 2017, astronomers finally caught a repeating FRB source from several bursts that emerged in a few hours. The burst source was found to have come from a galaxy 3 billion light years away in the deep Universe.

The large collecting area makes FAST the most sensitive telescope over the world, and its precisely controlled adaptive reflectors enable it to focus at an excellent precision and track on celestial targets.

In the trial open semester in 2019, Dr. LUO Rui, first author of the study, a PhD student from Peking University, hoped to use FAST to see if a radio burst FRB 180301 repeats or not. Fortunately, four bursts were detected during the two-hour observation session on July 16, 2019. This was an exciting result, but no bursts were detected in the four-hour observation on September 11, 2019.

Considering the uncertainty of the originally reported position from the first discovery by the Australian telescope, a research team led by Prof. LI Kejia from Peking University, Prof. HAN Jinlin from the National Astronomical Observatories of Chinese Academy of Sciences (NAOC), and Prof. ZHANG Bing



FAST revealed the mystery of fast radio burst FRB 180301 by the first discovery of diversity of polarization angle swings (red curves in the top panels). (Image by LUO *et al*) from University of Nevada, Las Vegas, USA discussed and changed the strategy for observations. In the subsequent observations, they monitored the target by using the central beam of the 19-beam receiver of the FAST and made the full-polarization data recorded.

On October 6 and 7 alone, FAST detected 11 bursts in observation sessions lasting for six hours. Totally, it detected 15 bursts in 12 hours in this observation campaign. The intensity profiles of these bursts are quite different from each other, but definitely they have come from the same source, indicating properties similar to the repeating burst sources previously found, with a similar distance of three billion light-years away, and a similar burst rate but much weaker luminance.

The most intriguing results come from the careful analysis on the polarization signals of the 11 radio bursts recorded by FAST on October 6 and 7. The polarization properties of seven of them could be well-measured, which showed not only interesting swings of polarization, but also the diversity of swings.

Such a diverse polarization behavior had never been seen in any radio burst previously. It favors the FRB generation model that the bursts are produced in the magnetosphere of compact stars with extremely strong magnetic fields, such as neutron stars, and disfavors the shock model that the bursts are produced by jets of plasma as proposed by many scientists.

In the past, polarization signals from only a few of some 30 bursts have been recorded, either showing flat polarization angle swing, *i.e.* constant polarization direction of radio waves, or variable position angle in one-off bursts. The significant results obtained by FAST observations settle down the debates between the two schools of theoretical models.

As of today, FAST has conducted intense astronomical observations to many celestial objects, and has discovered more than 230 new pulsars in the last few years.

This paper can be accessed at https://www.nature.com/articles/s41586-020-2827-2

(NAOC)