FAST Detects First Evidence for the 3D Spin-velocity Alignment in a Pulsar

Pulsars – another name for fast-spinning neutron stars – originate from the imploded cores of massive dying stars through supernova explosion.

Now, more than 50 years after the discovery of pulsars and confirmation of their association with supernova explosions, the origin of the initial spin and velocity of pulsars is finally beginning to be understood.

Based on observations from the Five-hundred-meter Aperture Spherical radio Telescope (FAST), Dr. YAO Jumei, member of a team led by Dr. LI Di from the National Astronomical Observatories of Chinese Academy of Sciences (NAOC), found the first evidence for three-dimensional (3D) spin-velocity alignment in pulsars.

The study was published in *Nature Astronomy* on May 6. It also marks the beginning of in-depth pulsar research with FAST.

For decades, scientists have found observational evidence for spin-velocity alignment in young pulsars. The relationship between pulsars' spin axis and spatial velocity vectors thus revealed, however, has largely been restricted to a 2D sky plane perpendicular to the line of sight, due to the hardship in constraining their radial velocity.

Focusing on PSR J0538+2817 in the supernova remnant (SNR) S147 and through the scintillation technique, Dr. YAO obtained its radial location with respect to the SNR boundary and its radial velocity for the first time. "Then we got the 3D velocity by combining the transverse velocity measured by Very Long Baseline Interferometers," said Dr. YAO. With the 3D spin axis estimated based on the polarization analysis, a best fit angle of about 10 degrees between these two vectors was found, which is the first of such measurements in 3D.

FAST is currently the world's most sensitive single aperture radio telescope. "This represents a kind of tour-de-force in pulsar data analysis. Through FAST observation, our team has accomplished more detections, which promise to further help reveal the origin of pulsar spin-kick," said Dr. LI, chief scientist of FAST and one of the corresponding authors of the study.

This work has been partly supported by CAS International Partnership Program. Major collaborators of the study include those from the Xinjiang Astronomical observatory of the Chinese Academy of Sciences, the Australia Telescope National Facility, University of California, the Max Planck Institute for Radio Astronomy, and Oberlin College.

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