Research in Astronomy and Astrophysics, 25:018001 (2pp), 2025 January
https://doi.org/10.1088/1674-4527/ada3b9
CSTR: 32081.14.RAA.ada3b9

FAST and Furious: Pulsar Discoveries from the World's Largest Telescope Improve Our Understanding of the Transient Sky*

Duncan R. Lorimer[1,2]
[1] Department of Physics and Astronomy, West Virginia University, Morgantown, WV 26506-6315, USA; duncan.lorimer@mail.wvu.edu
[2] Center for Gravitational Waves and Cosmology, West Virginia University, Chestnut Ridge Research Building, Morgantown, WV 26505, USA
Received 2024 December 23; accepted 2024 December 23; published 2025 January 31

Key words: (stars:) pulsars: general – stars: neutron – ISM: general

The Five-hundred-meter Aperture Spherical Telescope (FAST) is living up to its promise as one of the world's premiere pulsar finding instruments. At the center of FAST's many significant pulsar discoveries (which in total number 1000 from all projects to date) is the announcement by Han et al. (2025) of a further 473 pulsars. The new discoveries are the latest installment from the FAST Galactic Plane Snapshot Survey (GPPS), bringing its total to 751 pulsars. Full details of the design and observational setup of the FAST GPPS can be found in Han et al. (2021). In brief, the survey is covering the northern Galactic plane in the FAST sky with latitudes $|b| < 10°$ with 5 minute pointings using the 19-beam 1.4 GHz receiver on the FAST telescope, achieving a sensitivity to pulsars as faint as a few μJy. To date, with just under 25% of the total survey area completed, the discoveries include 107 rotating radio transients (RRATs), 177 millisecond pulsars (MSPs) and 157 binary pulsars. With most of the observations close to the Galactic plane complete, the rate of future discoveries will likely fall off slightly, but GPPS is set to eclipse the Parkes Multibeam Pulsar Survey (Manchester et al. 2001) as the most successful pulsar survey to date.

To demonstrate the sensitivity of GPPS to MSPs, Figure 1 shows a polar diagram of all currently known MSPs as a function of Galactic longitude. The over density along the directions of the Galactic plane that are visible from FAST (and formerly the Arecibo observatory) is immediately apparent. Although this diagram shows that the sample is still heavily biased, it emphasizes the important role that FAST is playing in our understanding of the MSP sample. Indeed, of the ~550 Galactic MSPs currently known, around one-third of them have been found by the FAST GPPS! Future analyses including these and forthcoming MSPs from GPPS will no doubt inform our knowledge of the Galactic population.

Similar impacts from the FAST GPPS are being seen in the Galactic population of RRATs. The new discoveries presented by Han et al. (2025) clearly underscore that these objects are part of the neutron star zoo. The working definition for RRATs, as objects that are detectable only through their single-pulse emission, is clearly telescope dependent (Keane & McLaughlin 2011). More sensitive observations from future instruments will likely show fainter pulses that are beyond the reach of even FAST. However, for now, the discoveries of RRATs are important, as single-pulse searches provide a way to maximize the number of sources found by any pulsar survey. Among the single-pulse sources found by the FAST GPPS are a number of fast radio bursts (FRBs). Among these, FRB 20240224 has a substantial dispersion measure that is over 1300 cm^{-3} pc as predicted by models of the free electrons in the Galaxy. This discovery underscores FAST's potential to find high-redshift FRBs which have important cosmological implications (Zhang 2018).

The discovery of over one hundred binary pulsars in the FAST GPPS to date has already resulted in a number of exciting individual systems. These include the double neutron star binary PSR J1901+0658 (Su et al. 2023), the most compact binary to date, PSR J1953+1844, with an orbital period of only 53 minutes (Pan et al. 2023), and a number of MSP–white dwarf systems in which Shapiro delay measurements are already available (Yang et al. 2025). Without a doubt, many more interesting systems will be found that will challenge and inform our understanding of the origin and evolution of neutron stars in binary systems.

Finally, in addition to detecting many new pulsars, FAST GPPS has also made important contributions to our understanding of previously known sources. The high-quality of the observations of these pulsars, which are generally brighter than the newly discovered ones, means that previously unidentified features can be seen. The so-called "dwarf pulses" were first spotted in FAST GPPS observations of the pulsar B2111+46 (Chen et al. 2023) as narrow faint pulses within the pulse window during the off states of this well-known nulling pulsar. Understanding the observations of this phenomenon in the coming years will help us to understand the challenging problem as to how pulsars radiate.

In summary, the FAST GPPS is providing a wealth of new discoveries and high-quality observations of pulsars that is set to profoundly impact our understanding of the pulsar and FRB populations. As I write this summary during the closing sessions of the International Pulsar Symposium in Guiyang, China (2024 December), the impact of the GPPS is already being

*This is the News and Views for the FAST Galactic Plane Pulsar Snapshot survey VI by Han et al. (2025, https://doi.org/10.1088/1674-4527/ada3b7) in this issue.

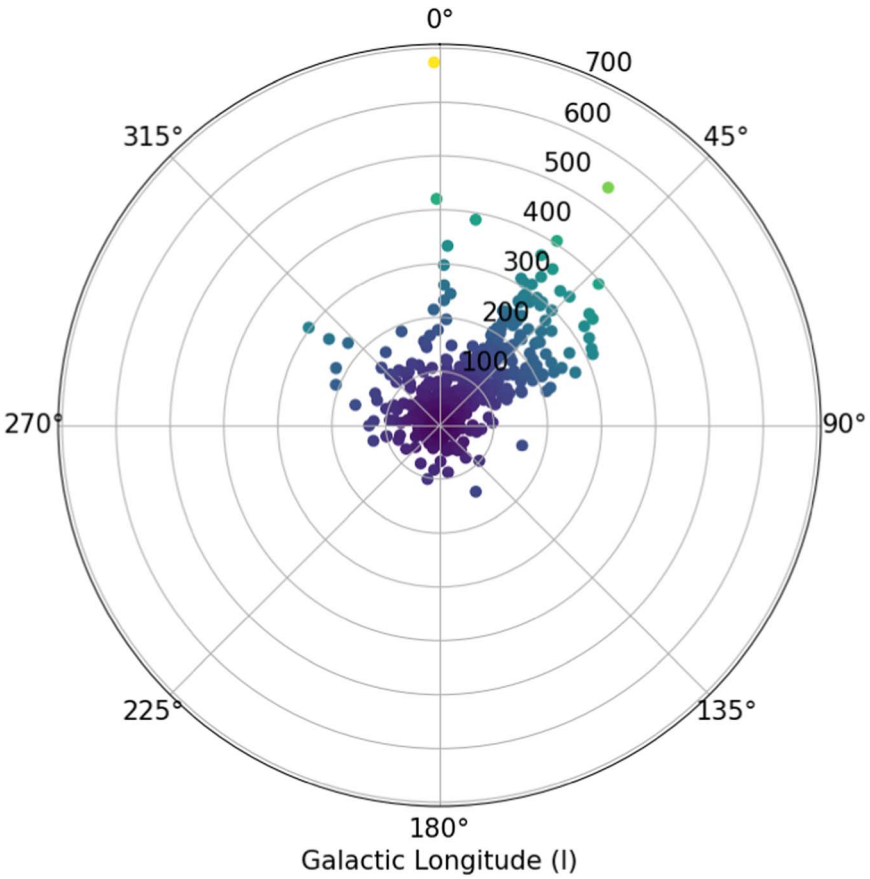

Figure 1. Distribution of pulsar dispersion measures as a function of Galactic longitude. The labels on each of the concentric circles correspond to the dispersion measure (in units of cm^{-3} pc) along that direction.

absorbed by the astrophysical community, and I look forward to further discoveries as the survey continues in the coming years.

References

Chen, X., Yan, Y., Han, J. L., et al. 2023, NatAs, 7, 1235
Han, J. L., Wang, C., Wang, P. F., et al. 2021, RAA, 21, 107
Han, J. L., Zhou, D. J., Wang, C., et al. 2025, RAA, 25, 014001
Keane, E. F., & McLaughlin, M. A. 2011, BASI, 39, 333
Manchester, R. N., Lyne, A. G., Camilo, F., et al. 2001, MNRAS, 328, 17
Pan, Z., Lu, J. G., Jiang, P., et al. 2023, Natur, 620, 961
Su, W. Q., Han, J. L., Wang, P. F., et al. 2023, MNRAS, 526, 2645
Yang, Z. L., Han, J. L., Wang, T., et al. 2025, RAA, 25, 014002
Zhang, B. 2018, ApJL, 867, L21