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A hard stare at a bursting radio source with the world's largest telescope

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Fast radio bursts (FRBs) were first discovered (Lorimer et al. 2007) serendipitously during a search for radio pulses in archival data in 2007. In the intervening period, FRBs have become an active area of astrophysical research that has attracted a diverse community of several hundred astronomers around the world. Although on average 1000 s of FRBs reach the Earth each day, they are very hard to detect due to their short duration and random location in the sky. Using a variety of telescopes, a picture of these sources is now emerging that depicts FRBs as being likely attributed to multiple classes of objects of cosmological origin. The four papers (Zhou et al. 2022; Zhang et al. 2022; Jiang et al. 2022; Niu et al. 2022) published in this issue provide one of the deepest studies of an FRB carried out to date, FRB 20201124A.

Out of the 636 FRBs currently in the public domain, FRB 20201124A is one of only 24 known to repeat. Given the difficulties of observing FRBs, there is much debate as to whether all FRBs repeat or not. Evidence in favor of multiple FRBs populations comes from the different morphologies seen in the FRB sample so far: one-off bursts tend to be simple in structure and occupy all of the frequency band for a typical observation; repeaters are broader and more complex and predominantly narrow-band. The number of sources, however, is still limited and the current study is important in that it provides very sensitive follow-up observations of FRB 20201124A which was recently associated with a nearby galaxy at redshift 0.0979. The unique sensitivity of the Five Hundred Meter Aperture Spherical Telescope (FAST, Nan et al. 2011) provides the opportunity to characterize the emission of this source far better than more distant FRBs.

Zhou et al. (2022, Paper I) and Zhang et al. (2022, Paper II) describe the catalog of over 800 pulses which were collected during a four-day frenzy of activity in September 2021 during which the burst rate increased exponentially, peaking at over 540 bursts per hour before the source activity ceased. The bursts cluster within the band centered preferentially at two frequencies and show a variety of drifting behavior. The wait time distribution between successive bursts is shown to be clearly bimodal with peaks at 50 ms and 10 s. The energy distribution of the bursts is also shown to be bimodal. Are the two modalities correlated, and can this be observed in other repeaters? Jiang et al. (2022, Paper III) details polarimetric properties of the brightest pulses which show variations in the rotation measure and degree of polarization which is somewhat reminiscent of that seen in radio pulsars. Finally Niu et al. (2022, paper IV) describes the so far unsuccessful attempts to search for any periodicity in the 1 ms to 100 s range within the sample of bursts. For some bursts with complex multi-peaked components, there are tantalizing hints of millisecond periodicities, but none currently observed are statistically significant. While the results appear to place constraints on putative magnetar magnetic fields, it would be interesting to study the effect of masking a periodicity from pulses emitted from widely differing rotational phases. Ergo: FRB 20201124A could be a rotating neutron star that emits pulses in a way that makes a fundamental periodicity impossible to find.

Nature has provided an exciting repeater in FRB 20201124A. While the properties revealed by this study show some similarities with other repeaters, interesting questions remain. Further study of this and other repeating sources is encouraged. Like the original FRB discovery, revisiting archival data with fresh eyes and different techniques may well prove fruitful. Some caution is necessary, however. The rich observations here are just a snapshot (four days in the life) of a very complicated object. Like the study of radio pulsars, determining the intrinsic processes underlying the source will likely be challenging but well worth the effort.

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