

The Era When Pulsars Meet FRBs

May 11-16, 2025, Dream Field near FAST, Guizhou, China

Trombones, Profile Broadening, and Frequency-Dependent Activity Windows: Connecting PSR B0950+08 and FRB 20201124A

Anna Bilous

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Abstract: In this talk, we review the properties of two seemingly disparate sources of transient radio emission: a generic nearby non-recycled pulsar PSR B0950+08, and the prolific repeating FRB source FRB 20201124A. Despite the six-order-of-magnitude difference in distance, and the truly gigantic disparity in spectral luminosity, both sources exhibit spectral drift across their single pulses – commonly referred to as the “sad trombone” effect in FRBs. For PSR B0950+08, the drift occurs at lower radio frequencies and the pulsar displays both the classical downward “sad trombone” and the less common (for FRBs) upward “happy trombone” drift patterns. We demonstrate how such drift arises naturally within the curvature radiation model through radius-to-frequency mapping in inclined dipole magnetosphere, and show that in the regime of sparse sparking, predominantly sad trombones are produced, reminiscent of the spectral morphology seen in FRBs.

We further highlight another classical pulsar phenomenon—the widening of average pulse profiles at lower observing frequencies—and draw a parallel with recent low-frequency detections of FRB 20201124A using GMRT, which occurred only hours after FAST had firmly recorded a quenching of L-band emission. We interpret this as evidence for frequency-dependent activity windows, and place it within the framework of ultra-long-period magnetars. Using standard tools for determining pulsar magnetospheric geometry, we explore the possible magnetospheric structure of FRB 20201124A and argue that its observed phenomenology is consistent with emission from closed field lines. Our results add to the growing evidence that radio emission from FRBs and pulsars share more than just superficial phenomenology, and may originate from common physical processes.

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Fast radio bursts in the era of MeerKAT and the SKA

Manisha Caleb

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Abstract: Fast Radio Bursts (FRBs) are millisecond-duration flashes of radio emission that offer a unique tool for probing the high-redshift universe. By measuring their dispersion as they travel through the Universe, FRBs provide a direct way to study the distribution of baryons in the Universe, the state of the intergalactic medium (IGM) at early cosmic times and even cosmic reionization. While the precise mechanisms powering FRBs remain an open question, strong evidence links at least a subset of these bursts to highly magnetized neutron stars, or magnetars. The 2020 detection of an FRB-like burst from the Galactic magnetar SGR 1935+2154 provided a breakthrough, demonstrating that magnetars can produce FRBs under certain conditions. However, key questions remain: Are all FRBs produced by magnetars? What physical processes drive their extreme radio emission? And how do their host environments influence burst activity?

In this talk, I will review the current observational landscape of the FRB population, with a focus on recent discoveries from the MeerTRAP project at the MeerKAT radio telescope in South Africa. MeerTRAP's real-time searches are detecting and localizing FRBs at cosmologically significant distances, providing crucial constraints on their host galaxies and environments. Early JWST follow-up observations are beginning to shed light on their high-redshift environments. Additionally, the discovery of hyperactive repeaters with MeerKAT is reshaping our understanding of the diversity of FRB sources. I will discuss the implications of these findings for FRB progenitor models and their potential as cosmic probes, as well as the exciting future of FRB studies in the era of next-generation radio telescopes.

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Analysis and modeling of the rapid polarization rotations in single pulses of B1919+21

Shunshun Cao

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Abstract: In more than one third of B1919+21's single pulses, polarization angle (PA) is found to rotate quasi-monotonically with pulse longitude, by over 180 or even 360 degrees. Some single pulse PA even rotates by over 540 degrees. Besides, the frequency dependence of such phenomenon for B1919+21 is weak. We have attributed the extreme rotations to summations of orthogonal wave modes in the pulsar magnetosphere and have estimated the phase lag between wave modes in a paper (arXiv:2411.18999). I will first introduce the paper, and then present some more recent effort on understanding the polarization rotations in B1919+21.

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Pulsar Timing with single pulses

Siyuan Chen

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Abstract: The conventional pulsar timing technique stacks a large number of single pulses on top of each other to create a stable average profile to be matched against a template profile. This method allows us to get one very precise time of arrival (TOA) from a minutes-to-hours-long observation. However, we know that individual pulses may not be as stable as we would like. Their variation introduces an intrinsic white noise, sometimes called jitter, to pulsar timing, which can limit the precision we can achieve. Recent high S/N observations from FAST and MeerKAT have produced the most sensitive single pulse data sets to date. These have revealed phenomena previously not seen. In my presentation I try to point out some aspects of single pulses for their timing stability. Which can serve as the starting point to develop new methods to allow for even higher precision pulsar timing.

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Millimeter wave emission of radio transients

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Abstract: Radio transients, such as pulsars and fast radio bursts (FRBs), are primarily detected at centimeter radio wavelengths, given their higher luminosities at lower frequencies. However, could we study them at millimeter waves? For pulsars, this window remains poorly studied, but it represents a stepping stone to connect the radio emission with infrared/optical and to discern where the transition from coherent to incoherent emission occurs. For FRBs, detections have been made up to 8 GHz. Therefore, studying radio-emitting NS at mm-waves offers a direct link to connect to FRBs and whether they could be detected above the classic cm-wave window.

In this presentation, we will explore new capabilities at ALMA which enable the observations of radio transients from 35 up to 230 GHz. When ALMA's 12-m antennas are coherently combined, it reaches an equivalent sensitivity of a 80+ meter dish, enabling high-time-resolution of transients at mm-wavelengths with unparalleled sensitivity. We will explore the results from the running campaigns at ALMA and how the detected sources, among them the Galactic Center magnetar, help us to link with FRBs.

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Polarization arcs in radio pulsars

Jaroslav Dyks

Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences

Abstract: Observed radio pulsar polarization exhibits complex effects that belong to the realm of "beyond-the-rotating-model". These involve arcs formed by data points on the Poincare sphere, or extended data distributions within the Stokes parameter space. They are observed on different time scales. I will describe main observed types of such phenomena and present interesting theoretical questions they raise, including possible interpretations.

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The Fundamental Problems in Binary Star Evolution

Hongwei Ge

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Abstract: This report first briefly highlights the framework and importance of single-star and binary-star evolution. Then, we show why stability criteria of rapid mass transfer and common-envelope evolution are fundamental in binary star evolution: i.e., they determine the mass, mass ratio, and orbital distribution of many important systems, such as X-ray binaries, type Ia supernovae, and merging gravitational-wave sources. In the limit of extremely rapid mass transfer, the response of a donor star in an interacting binary becomes asymptotically one of adiabatic expansion. We introduce how we built the adiabatic mass-loss model and systematically surveyed the thresholds for dynamical timescale mass transfer over the entire span of possible donor star evolutionary states. We finally show many works that apply our results to related binary star objects, double black holes/neutron stars, double white dwarfs, and post-common-envelope stars.

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Periodicity in repeating fast radio bursts

Yongfeng Huang

Nanjing University

Abstract: Fast radio bursts (FRBs) are Fierce radio flashes from the deep sky. Abundant observations have indicated that highly magnetized neutron stars might be involved in these energetic bursts, but the underlying trigger mechanism is still unknown. Especially, the widely expected periodicity connected to the spin of the central engine has never been discovered, which leads to further debates on the nature of FRBs. Recently, we found a 1.7 s period in the repeating source of FRB 20201124A. This is an active repeater, from which more than 2800 FRBs have been observed on a total of 49 days. The phase-folding method is adopted to analyze the bursts on each day separately. While no periodical signal is found for the bursts on most days, a clear periodicity does appear on two specific days, i.e. a period of 1.706015(2) s on MJD 59310, and a slightly larger period of 1.707972(1) s on MJD 59347. A period derivative of $6.14\text{E-}10$ s/s can be derived from these two periods, which further implies a surface magnetic field strength of $1.04\text{E}15$ G and a spin-down age of only 44 years for the central engine. It is thus concluded that FRB 20201124A should be associated with a young magnetar.

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Recent results on PSR J1740+0948 observed by LHAASO

Zhe Li

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Abstract: The closest Pulsar PSR J1740+1000, located at a high Galactic latitude, powers a Bow Shock Pulsar Wind Nebula (BSPWN) which exhibits a long X-ray tail. While the spatial offset between the pulsar and the gamma-ray source reaches 0.2° even over 100TeV, this is not appeared at the current TeV Halo sources, and the centroid of the gamma emission is approximately located at the extension of the X-ray tail. We speculate that the UHE γ ray emission observed by LHAASO may originate from re-accelerated electron/positron pairs which are advected away in the bow-shock tail, rather than being associated with TeV halos linked to PSR J1740+1000. This finding suggests that TeV halos may not be a common occurrence around energetic middle-aged pulsars.

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A possible link between pulsars, magnetars and fast radio burst

Kuo Liu

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Abstract: Quasi-periodic microstructure is a peculiar emission phenomenon that has long been observed in canonical pulsars. In recent years, advancements in sensitivity and rapid data recording systems have enabled its detection in other classes of neutron stars, including millisecond pulsars, rotational radio transients, and magnetars. Furthermore, it has been identified in radio transient sources across different timescales, including fast radio bursts and those with periods on the order of tens of minutes. In this talk, I will provide an overview of quasi-periodic microstructure detection in various radio sources. Based on these findings, I will explore a potential connection between rotation-powered neutron stars, magnetars, and fast radio bursts. This possible link may offer insights into an underlying periodicity in fast radio bursts.

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PSR J0901-4046 – A slow radio pulsar as the link between LPTs and FRBs?

Rui Luo

Guangzhou University

Abstract: The radio-emitting neutron stars are normally observed as radio pulsars with spin periods ranging from milliseconds to tens of seconds. In recent years, however, the discovery of long-period radio transients (LPTs) has posed a new challenge to the classical theoretical framework of neutron stars' magnetospheric dipole model. Fast Radio Bursts (FRBs), which are extremely bright millisecond-duration radio transients usually coming from distant universe, have been proved that some of them can be produced by magnetars. Intriguingly, FRBs can exhibit similar apparent characteristics to the single pulses from Galactic magnetars.

PSR J0901-4046 is a radio pulsar with a period of 76 seconds discovered by MeerKAT. We have been monitoring PSR J0901-4046 using the Parkes 64-m radio telescope and detected single pulses with similar durations to fast radio bursts (FRBs), notably containing quasi-periodic substructures similar to some FRBs. Importantly, we obtain the integrated profile of PSR J0901-4046 by timing it for hours, which is the longest period radio pulsar with integrated profile so far. We also measure the polarization properties of this pulsar so that some constraints on the classic dipole pulsar emission model can be made. Additionally, we call for multiwavelength observations for this pulsar by using optical telescope to seek the possible companion star in a binary. The new findings might connect LPTs and FRBs in terms of radio emission mechanism, and provide us with more insights into the nature of FRBs. Further targeted search for long-period radio pulsars and LPTs would shed light on the population of magnetars in the Milky Way.

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Temporal and Polarization Characteristics of Fast Radio Bursts

Jiarui Niu

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Abstract: By investigating the similarities and differences between Fast Radio Bursts (FRBs) and pulsars, potential relationships between FRB origins and pulsars may be uncovered. Temporal analysis and polarization studies are particularly significant in this regard. Through temporal analysis, periodic characteristics of FRBs can be identified, which is crucial for understanding their central engines (e.g., pulsars or magnetars). By analyzing the polarization properties of FRBs, magnetic field environments around their sources can be inferred, different radiation mechanisms can be distinguished, and propagation processes of FRBs in extreme conditions can be understood.

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Magnetospheric Wave Emission from Magnetar Crust Quakes in Fast Radio Bursts

Yuanhong Qu

University of Nevada

Abstract: In this talk, I will present generic constraints from observations on intrinsic radiation mechanisms of FRBs. I will show that crust quakes of magnetars are vital for all kinds of wave modes in the magnetosphere. The elastic waves are produced by the incompressible shear perturbation in the magnetar crust and propagate perpendicular to the surface. Although the elastic waves in the crust are effectively incompressible, they directly couple to both compressible (fast magnetosonic) and incompressible (Alfven) waves in the magnetosphere. The two MHD waves are typically in the kilohertz band generated from magnetar crust quakes. Fast magnetosonic waves can be generated when the background magnetic field is not completely perpendicular to the surface. I will present 3D elasto-dynamics simulations of the entire crust and find that both fast magnetosonic waves and Alfven waves can be produced and both waves could have a comparable energy ratio. The star quake and associated magnetospheric wave emission are rapidly damped by magnetic coupling to the core. The quake is damped on a timescale ms. consistent with the observed magnetar burst durations. The results will be important for providing possible trigger mechanisms for generating FRBs. Finally, I will show that FRBs are likely generated via coherent inverse Compton scattering off low-frequency fast magnetosonic waves by bunches at a distance of a few hundred times the magnetar radius and discuss the observational implications including high degrees of linear and circular polarization, narrow spectra as observed in many bursts from repeating FRB sources.

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A single-pulse study of CRAFTS pulsars discovered at FAST

Rukiye Rejep

NAOC

Abstract: The Five-hundred-meter Aperture Spherical radio Telescope (FAST) has discovered more than 170 new pulsars in the Commensal Radio Astronomy FAST Survey. Based on the single-pulse observations of four CRAFTS pulsars, we investigated the single-pulse phenomena and polarization information including subpulse modulation, nulling, drifting, as well as orthogonal polarization jumps for these pulsars. In this talk, we will briefly discuss our findings and their implications for the magnetospheric physics and emission mechanisms.

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Dwarf pulses detected by FAST

Chen Wang

NAOC

Abstract: Pulsars radiate radio signals when they rotate. However, some old pulsars often stop radiating for some periods. The underlying mechanism remains unknown, as the magnetosphere during nulling phases is hard to probe due to the absence of emission measurements. Here we report the detection and accurate polarization measurements of sporadic, weak, narrow dwarf pulses detected in the ordinary nulling state of pulsar B2111+46 and via the Five-Hundred-Meter Aperture Spherical radio Telescope. Further analysis shows that their polarization angles follow the average polarization angle curve of normal pulses, suggesting no change of the magnetic-field structure in the emission region in the two emission states. Whereas radio emission of normal individual pulses is radiated by a ‘thunderstorm’ of particles produced by copious discharges in regularly formed gaps, dwarf pulses are produced by one or a few ‘raindrops’ of particles generated by pair production in a fragile gap of this near-death pulsar. In the subsequent research, we additionally detected dwarf pulses from ten pulsars.

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Binary origin of fast radio bursts

Fayin Wang

Nanjing University

Abstract: Fast radio bursts (FRBs) are a mysterious new class of extragalactic fast radio transients whose nature is presently unknown. This talk will introduce the latest research progress on fast radio bursts and cosmological applications, especially some evidences on the binary origin of some repeating FRBs.

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On the radio emission beam model of pulsars

Hongguang Wang

Guangzhou University

Abstract: Recent observations on PSR J1906+0746 revealed that the radio emission beam of this pulsar is inconsistent with either the conical beam model or the simple versions of fan beam model. In this talk we will discuss the implications of the radiation beam characteristics of this star for understanding pulsar radio emission and magnetospheric structure, including the effect of multipolar magnetic fields on the beam structure and the consistency between the radiation beam structures of the two magnetic poles.

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Emission and propagation in pulsar magnetosphere

Pengfei Wang

NAOC

Abstract: A theoretical model is proposed to account for curvature emission processes and subsequent propagation effects within pulsar magnetosphere. In the model, rotation plays an important part, which affects the trajectories of relativistic particles and hence the emission properties, especially polarization, and the mode (X and O) distributions. Numerical calculations of the model predict different polarization features for different plasma conditions. The model can naturally explain the orthogonal polarization modes, highly linearly polarized profile components, and the frequency dependence of linear polarization, etc. It also predicts the whole phase emission features, which are compared with FAST observations of the two bright pulsars, J0953+0755 and J1932+1059.

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Memory Effects in Repeating FRBs: Revealing Hidden Patterns in Burst Sequences

Ping Wang

IHEP, CAS

Abstract: Understanding the occurrence pattern of repeating fast radio bursts (FRBs) is crucial for uncovering their mysterious physical mechanisms. Recent analyses of high-quality datasets reveal a significant memory effect in the burst waiting times of repeating FRBs. Specifically, short waiting times tend to be followed by short ones, and long intervals by long ones, demonstrating clear temporal correlations. This phenomenon deviates from a purely stochastic Poisson process, indicating that burst sequences retain memory of past activities. Such memory effects suggest complex dynamical processes, potentially involving magnetar crust activities or magnetic reconnection events. This finding provides important constraints on theoretical models, bridging the gap between repeating and apparently nonrepeating FRB sources.

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Individual subpulses and their polarization properties in PSR B1916+14 observed by FAST

Tao Wang

NAOC

Abstract: The essential emission "cells" of coherent emission from pulsars give information on the emission process and propagation effects in the pulsar magnetosphere. The Five-hundred-meter Aperture Spherical radio Telescope (FAST) is super-sensitive to detect emission details of individual pulses. Among many pulsars observed by the FAST, a large number of well-resolved individual subpulses of PSR B1916+14 have been detected with a time resolution of $49\ \mu\text{s}$. These individual subpulses have a typical width of 0.15 ms and are highly polarized, with polarization position angles of linear polarization often deviating from the standard S-shaped curve.

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Propagation-induced Frequency-dependent Polarization Properties of Fast Radio Burst

Weiyang Wang

UCAS

Abstract: Frequency-dependent polarization properties provide crucial insights into the radiation mechanisms and magnetic environments of fast radio bursts (FRBs). We explore an analytical solution of radiative transfer of the polarization properties of FRBs as a strong incoming wave propagates in a homogeneous magnetized plasma. The case of a thermal plasma is studied in more detail. The rotational axis of the polarization spectrum undergoes precession with frequency on the Poincaré sphere when the medium has both strong Faraday rotation and conversion. Such precession on the Poincaré sphere could occur in hot or cold plasma with a strong magnetic field component perpendicular to the line of sight. The analytical solution with the mixing Faraday case offers a more physical description of the physical properties of the magnetic environment of FRBs than the empirical “generalized Faraday rotation” method commonly adopted in the literature. Significant absorption can exist in a dense plasma medium, which may give rise to a highly circularly polarized outgoing wave. The frequency-dependent Stokes parameters may be associated with reversing rotation measures or the presence of a persistent radio source around an FRB.

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The radiative subpulse modulation and spectral features of PSR B1929+10 with the whole pulse phase emission

Zhengli Wang

Guangxi University

Abstract: We observed PSR B1929+10 over a long-term scale using FAST. Our results demonstrate that this pulsar is a whole 360 degrees of longitude emission pulsar. In addition, we find at least 15 components of pulse emission in the average pulse profile and find interesting spectral features in them. Additionally, we identify 5 modes of subpulse modulation in various emission regions, which differ from the pulse components. We fit the observed polarization position angle (PPA) variations of this pulsar by the rotating vector model and then calculate some numerical results for the pulsar magnetosphere.

The timing and polarization of PSR J0002+6216

Yu Wei

Xinjiang Astronomical Observatory, CAS

Abstract: The combined timing analysis of data from the Five-hundred-meter Aperture Spherical Radio Telescope (FAST) and the Fermi Large Area Telescope (Fermi-LAT) confirmed that PSR J0002+6216 is not a hyper-velocity (exceeding 1000 km s^{-1}) pulsar. From this analysis, we determined the total proper motion of PSR J0002+6216 to be $\mu_{\text{tot}} = 39.05 \pm 15.79 \text{ mas yr}^{-1}$, which is consistent with Very Long Baseline Interferometry (VLBI) measurements to within 0.24σ . Moreover, two glitches were detected for the first time, which occurred on MJD 58850(17) and MJD 60421(6), respectively. The second glitch exhibited an exponential recovery process, with $Q = 0.0090(3)$ and $\tau_d = 45(3)$ days. Additionally, with FAST high-sensitivity observations, we measured the interstellar rotation measure (RM) and the three-dimensional (3D) orientation of the spin axis for the first time, and updated the dispersion measure (DM) of PSR J0002+6216. Currently, no variations in RM or DM have been detected. By combining the measured RM with the observed position angle of the spin axis, we determined that the intrinsic position angle of the pulsar's spin axis is $\psi_0(\text{intrinsic}) = 90^\circ \pm 5^\circ$. When we compared this with the proper motion position angle obtained from VLBI, we found a misalignment of approximately 23° between the spin and velocity angles of PSR J0002+6216. At present, pulsars with 2D spin-velocity angle measurements are unable to fully test the Janka et al. (2022) model. However, with more high-precision observational data in the future, we will be able to further test models related to pulsar birth.

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Single-pulse-based interstellar scintillation of compact radio sources

Ziwei Wu

NAOC

Abstract: In this presentation, I will briefly introduce the difficulties of doing interstellar scintillation studies using single pulses. Moreover, I will also introduce our progresses on this topic using FAST pulsar and FRB data set.

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Nonuniform structures and clustering in dense stellar matter

Chengjun Xia

Yangzhou University

Abstract: I will briefly discuss the properties and microscopic structures of nonuniform structures in dense stellar matter that arise from various types of first-order phase transitions. Based on a similar approach, the effects of clustering will also be addressed.

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High Galactic Latitude FAST Pulsar Search and Pulsar Radiation Studies

Xin Xu

Guizhou Normal University

Abstract:

We have conducted pulsar surveys at high Galactic latitudes using FAST and also studied these pulsar radiation properties. In the pulsar survey at high Galactic latitudes, we have discovered 20 new pulsars so far, including six millisecond pulsars (MSPs) with spin periods below 20 ms. Among these MSPs, there are five that have been identified in binary systems. And two of these MSPs have been obtain coherent timing solutions, while observations of the remaining MSPs are still being followed up. In the study of pulsar radiative properties, using FAST, in combination with Parkes and other radio telescopes, we have conducted a detailed study of pulsar radiative mechanisms, single pulses, polarization properties, and other related aspects. In this talk, we will briefly report our results on pulsar surveys, timing, and single pulses, among others.