The International Pulsar Symposium 2024

Abstract Book

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GuiYang, China

2024-12-13：

Session 1： Opening and leading lectures (Chairs：JinLin Han)

1-0 Background, organizing, and special guests for opening

1-1 Pulsars and the Parkes, Murriyang radio telescope

Author: Dick Manchester/George Hobbs
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Abstract: I will describe the current and planned pulsar research and observing systems for the Parkes, Murriyang radio telescope. In particular, I will highlight the new cryogenically-cooled phased array feed, the planned ultra-wide bandwidth receivers that will allow us to operate from 700 MHz to 30 GHz, the flexible GPU-based backend infrastructure, our data archives and processing systems. I will discuss key science projects such as the Parkes Pulsar Timing Array project and describe our pulsar searching goals.

1-2 Binary and Millisecond Pulsars

Author: Dunc Lorimer
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Abstract: Thanks to recent and ongoing surveys being carried out by a variety of large-scale facilities, the sample of binary and millisecond pulsars currently known in the Galaxy and its globular cluster system is growing rapidly. In this talk, we review some of the latest impacts of these discoveries on our understanding of these populations, and briefly look ahead to the future.

1-3 Gravity tests with binary pulsars

Author: Michael Kramer
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Abstract: This year marks the 50th anniversary of the discovery of the first pulsar in a binary system, PSR B1913+16, found in the summer of 1974 by Russell Hulse and Joseph Taylor. In the five decades since this groundbreaking discovery, many more binary pulsars have been identified, including remarkable systems like the double pulsar PSR J0737−3039A/B, where two active radio pulsars are detectable from Earth, and the triple system PSR J0337+1715. Binary pulsars have spurred extensive research in theoretical gravity and opened new experimental avenues for studying relativistic gravity. Notably, the comparison between binary pulsar timing data and

theoretical models has provided the first direct observational evidence that gravity propagates at the speed of light, as well as the first precise tests of the strong-field regime of relativistic gravity. This talk will review some of the ground breaking results, as well as present recent results.

1-4 Physical Processes in Pulsar Magnetospheres

Author: A. Philippov
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Abstract: In this talk, I will review recent progress in understanding the complex multi-scale physics of neutron star magnetospheres through the lens of first-principles numerical simulations. I will highlight pair production discharges near the stellar surface and radiative magnetic reconnection near and beyond the light cylinder. I will extensively discuss their role in powering the multi-wavelength non-thermal radiation of pulsars, which spans almost 20 decades in photon energy, from enigmatic coherent radio waves to recently detected 20TeV emission in Vela.

Session 2：Pulsar discovery - 1　(Chairs：Michael Kramer)

2-1 Discoveries of the FAST Galactic Plane Pulsar Snapshot Survey

Author: JinLin Han
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Abstract: The Five-hundred-meter Aperture Spherical radio Telescope (FAST) is the most sensitive telescope at the L-band (1.0-1.5GHz) and has been used to carry out the FAST Galactic Plane Pulsar Snapshot (GPPS) survey in the last 5 years. Up to now, the survey has covered one-fourth of the planned areas within $\pm10^{\circ}$ from the Galactic plane visible by the FAST, and discovered 751 pulsars, including 177 new millisecond pulsars and 107 new RRATs. The GPPS survey has discovered 8 pulsars with periods greater than 10~s including one with 29.77~s. During the FAST GPPS survey, we also detected previously known pulsars and updated parameters for 116 pulsars. In addition, we discovered 7 fast radio bursts plus one probable case with high dispersion measures indicating their extragalactic origin.

2-2 SMART survey for pulsars and fast transients

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Abstract: The Southern-sky MWA Rapid Two-meter (SMART) survey exploits the low radio frequencies and large field-of-view of the Murchison Widefield Array

(MWA) in Western Australia to survey the sky south of +30 degrees in declination for pulsars and fast transients. It will be the most sensitive pulsar survey in the southern sky in the frequency band of the low-frequency Square Kilometre Array (SKA-Low). The novelty of voltage recording employed for the survey offers a multitude of avenues for candidate confirmation and sky localisation, and enables the reprocessing of data to explore and develop new search algorithms and strategies. With the data collection phase for the survey 100% completed and the publication of the first tranche of papers and discoveries, the project has now attained a significant milestone.The ongoing first-pass (shallow survey) processing has resulted in the discoveries of several pulsars, including sub-pulse drifters and low-luminosity objects, as well as re-detection of over 200 pulsars. The project is currently transitioning to full-scale searches, wherein observations of 80-min dwell times will be processed using Fourier-domain acceleration, fast-folding algorithm and single-pulse search methods. In addition, semi-coherent (hybrid) de-dispersion techniques will be employed for increased sensitivity to short-period millisecond pulsars, and will employ the orbital acceleration and sideband searches to target pulsars in binary systems. With several Petabytes of data to process, the survey poses substantial challenges in both compute power and data management strategies, and the lessons learned will directly inform future large pulsar surveys, especially those planned with the low-frequency SKA. I will present an overview of the project as well as the progress to date, including science highlights, southern-sky pulsar census, and future plans.

2-3 GMRT high-resolution southern sky survey for pulsars and transients

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Abstract: Despite significant advancements in survey technologies over the past decade, the current catalog of approximately 3750 known pulsars represents less than 5% of the anticipated number of detectable radio pulsars. To address this challenge, we are conducting the GMRT High Resolution Southern Sky (GHRSS) survey dedicated to pulsars and transients using the GMRT. This survey operates at comparable or higher sensitivities compared to any other existing or ongoing low frequency surveys for the target sky in the southern hemisphere. The calculated theoretical sensitivity for a 10-minute pointing duration in GHRSS at 400 MHz, considering a 200 MHz bandwidth, is 0.25 mJy (~ 0.32 mJy for 120 MHz usable bandwidth). We conduct the fast Fourier transform (FFT, Staelin, 1969) based periodicity search to detect the short-period pulsars and also employ the Fast folding algorithm (FFA, Morello et al. 2020), a time domain search algorithm to the survey data. In total we have 31 discoveries from the GHRSS survey. Out of these we have discovered 22 pulsars including three MSPs and two mildly recycled pulsars using fast FFT based periodicity search to detect the short-period pulsars. We have discovered six long period pulsars using FFA based searches and explore the

possibility of existence of a hitherto undiscovered missing population of long-period and short-duty cycle pulsars. We have discovered three rotating radio transients(RRATs) from the GHRSS survey. We will discuss survey strategy, and will also present the long term timing solutions for the pulsars discovered in the GHRSS survey.

2-4 Search for pulsars and transients by the Large Phased Array

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Abstract: The search and investigation of pulsars is one of the main tasks for a Large Phased Array (LPA). Using the high sensitivity of the antenna and daily observations, it was possible to find about 80 canonical pulsars and about 100 rotating radio transients (RRAT). The search for pulsars was done using P/DM maps showing S/N harmonics in the power spectra. Neural networks are used to search for RRAT. Daily observations at declinations -9o<dec.<+55o make it possible not only to search for new pulsars, but also to investigate known and new sources. The study was carried out at the expense of a grant Russian Science Foundation 22-12-00236.

Session 3： Pulsar discovery - 2 (Chairs：Scott Ransom)

3-1 Finding more and more gamma-ray pulsars with the Fermi LAT

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Abstract: Over 300 pulsars are seen to pulse in GeV gamma rays acquired with the Large Area Telescope (LAT) on the Fermi satellite. Many more may be waiting for discovery: of the >2000 LAT sources with no counterpart known at other wavelengths, hundreds are non-variable, with pulsar-like spectral shapes and sky distributions. In addition, population syntheses typically predict as much as twice the current LAT pulsar sample. However, detecting gamma-ray pulsations will be difficult for most of the new ones, whether through blind searches of the gamma-ray data, or using long-term phase-connected rotation ephemeredes for radio pulsars. I will describe the sample of gamma-ray pulsars in the 3rd LAT Pulsar Catalog, and the ongoing work to transform candidates into discoveries. I will focus on the opportunities that FAST provides to identify the radio-faint, gamma-loud pulsars hidden in the LAT data, highlighting some of the science that further discoveries enable.

3-2 Isolated neutron stars from X-ray survey data

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Abstract: Since the discovery of the first radio pulsar, the known population of neutron stars in our Galaxy has grown to over 3,700. A select few of these, observed exclusively in soft X-rays, are crucial for exploring aspects of neutron star phenomenology and evolution that cannot be addressed by the broader population. In this contribution, I review their properties and highlight how the XMM-Newton Observatory and SRG/eROSITA have complemented our understanding of Galactic neutron stars. I also summarise ongoing follow-up efforts to identify new thermally emitting isolated neutron stars, particularly with XMM-Newton and FAST, and discuss prospects for future investigations in light of the eROSITA All-Sky Survey and the EU H2020 XMM2ATHENA project.

3-3 A multi-wavelength search for new pulsar candidates in compact binaries

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Abstract: We present our attempts to find new pulsars in compact binaries showing ellipsoidal variation (EV) signatures, by utilizing time-domain data from the Zwicky Transient Facility (ZTF). First, we focus on spider pulsar systems which typically emit gamma-rays originated from inter-binary interactions and thereby look for EV-type light variation within error ellipses of unassociated gamma-ray sources sourced from the 4FGL-DR3 catalog. Our search reveals a total of 194 EV-type binary stars, subsequently refined to 22 candidates which are situated within expected spider pulsar positions in Gaia color-magnitude diagrams. Second, we search for pulsars around 12, 000 Extremely Low-mass White Dwarfs (ELM WDs, or candidates thereof) reported in the literature. Again, we searched for EV-type lightcurves with orbital periods shorter than one day. 23 such systems were found, with 18 being newly discovered. Notably, four targets have companion mass exceeding one solar mass. Radio pulsation searches were carried out but no convincing new pulsars have been found.

3-4 Hunting spider pulsars: three new candidates and optical modelling of a confirmed one

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Abstract: Compact binary millisecond pulsars, also known as "spiders", host the most massive neutron stars ever observed to date. Expanding the currently known spider

population holds the key to determining the maximum neutron star mass, which has crucial implications for nuclear physics and gravitational wave astronomy. Although most of these systems are found from radio follow-up of Fermi-LAT sources, searching for the variable optical emission of their companions can reveal a hidden population of spiders that are highly obscured at radio wavelengths.

We present the discovery of three variable optical counterparts to the pulsar-like Fermi unidentified sources 3FGL J0737.2−3233, 3FGL J2117.6+3725 and 3FGL J2221.6+6507, which we identify as new spider candidates. Their optical light curves show a flux modulation amplitude larger than 0.3 mag in the sub-day period range and effective temperatures of 5000−6000 K, all properties consistent with the known sub-type of redback binary millisecond pulsars. If confirmed as a millisecond pulsar, 3FGL J0737.2−3233 would be the closest known spider to Earth (D=659 pc, from Gaia-DR3 parallax). These results will not only facilitate future radio observations of these three candidates, but will also allow us to measure their neutron star masses via optical light curve modelling. We also report the discovery of the variable optical counterpart of a newly found redback. Our preliminary findings indicate an unusual asymmetric irradiation of its companion star by the pulsar wind and a heavy neutron star with a mass of 1.8 MSun.

3-5 Harnessing the power of reprocessing pulsar surveys

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Abstract: Discovering new pulsars has long been a key objective in pulsar astronomy. Over the years, numerous surveys have been conducted to expand the pulsar population and discover interesting systems. But, to fully uncover all potential pulsars within a survey, it is necessary to reprocess the data using new search algorithms and classify a plethora of pulsar candidates in more sophisticated ways. However, due to computational limitations, only a handful of pulsar surveys have been reprocessed to date.

In this talk, I will present the results of GPU-accelerated reprocessing of large scale pulsar surveys conducted with the Parkes Radio Telescope (Murriyang) in Australia. I will explain how the use of straightforward search techniques has led to the discovery of 89 previously undetected pulsars, including some particularly interesting finds. Additionally, I will discuss our ongoing efforts to reprocess the Green Bank North Celestial Cap (GBNCC) pulsar survey conducted with the Green Bank Observatory in the US. I will emphasize the importance of these efforts in expanding the Galactic pulsar population for current and future pulsar surveys. Furthermore, I will highlight our initiative to engage citizen scientists from around the globe in the classification of pulsar candidates through the citizen science platform "Zooniverse".

3-6 High Galactic Latitude FAST Pulsar Search and Pulsar Radiation Studies

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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 6 millisecond pulsars (MSPs). Among these MSPs, there are 5 that have been identified in binary systems. And three 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. our research results will contribute to the understanding of the radiation mechanism and radiation geometry of pulsars.

3-7 A pulsar possibily associated with an open cluster

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Abstract: More than 300 pulsars have been discovered in Galactic globular clusters, establishing a strong correlation between stellar and pulsar density and opening a window to study stellar evolution. However, no pulsar has been reported in open clusters, which outnumber globular clusters and also have relatively high stellar densities. In this talk, I will present a new pulsar, J1921+37, in the same line-of-sight of NGC 6791, which is one of the most massive and old open clusters in our Galaxy. According to the NE2001 electron density model, J1921 has a distance comparable to that of NGC 6791, making the pulsar a likely association with NGC 6791. I will further discuss the likelihood of finding pulsars in NGC 6791 and the possible formation mechanisms of J1921.

3-8 A Search for Radio Pulsars in Supernova Remnants Using FAST with One Pulsar Discovered

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Abstract: We report the results of a search for radio pulsars in five supernova remnants (SNRs) with the FAST telescope. The observations were made using the 19-beam receiver in "snapshot" mode. The integration time for each pointing was 10 min. We discovered a new pulsar, PSR J1845-0306, which has a spin period of 983.6 ms and a dispersion measure of 444.6 ± 2.0 cm-3ṡpc, in observations of SNR G29.6+0.1.

To judge the association between the pulsar and the SNR, further verification is needed. We also re-detected some known pulsars in the data from SNRs G29.6+0.1 and G29.7-0.3. No pulsars were detected in the observations of the other three SNRs.

3-9 A search for binary millisecond pulsars in the image-plane

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Abstract: 'Spider' systems are a rare class of eclipsing pulsars where the millisecond pulsar (MSP) ablates material from a companion star. This creates an ionised medium which can absorb the radio pulses and causes the MSP to be eclipsed for a large fraction of its orbit. A population of MSPs may be responsible for the excess γ-ray emission observed in the Galactic centre. Traditionally, these systems have been detected using pulsation searches, but this approach faces difficulties in the Galactic centre due to the effects of scattering and dispersion. These difficulties are not an issue in the image plane, making it a more effective approach in detecting 'spider' systems in this region. The development of the Square Kilometer Array (SKA) precursors allows for image-plane searches that are more sensitive to detecting such systems and allows us to search a wide frequency range that was not previously available.

A recent monitoring campaign of the Murchison Widefield Array has led to the discovery of four new transients. Their eclipse-like variability, steep spectra, and γ-ray associations imply that they could be 'spider' systems producing both radio and γ-ray emission. In this talk, I will present the discovery and follow-up of these four sources. They have been observed with ASKAP Variables and Slow Transient survey (VAST), Parkes radio telescope 'Murriyang', upgraded Giant Metrewave Radio Telescope, and the Australia Telescope Compact Array. I will also discuss the possible reasons behind the non-detection of millisecond radio pulsations, constraints on the companion stars, theories regarding the eclipse mechanism, and properties of the eclipsing medium. Finally, I will outline our plans to search for more of these sources with VAST, providing further opportunities for discovery and study, that will allow us to better estimate the total population in our Galaxy, and whether MSPs are responsible for the observed γ-ray excess.

3-10 RRATs discovered by FAST GPPS survey

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Abstract: Single-pulse search has become an essential aspect of modern radio telescopes. The GPPS survey, utilizing the high sensitivity of the FAST telescope, has successfully discovered a large number of pulsars and faint radio transients, including

numerous RRATs and FRBs. This talk introduces an efficient single-pulse search pipeline developed for FAST, detailing the substantial findings of RRATs and FRBs within the FAST GPPS survey and presenting the analysis results of these intriguing sources.

3-11 Search for RRAT on three years of data with LPA

Author: Elena Bryliakova
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Abstract: The search for rotating radio transients (RRAT) was done at the frequency of 111 MHz at declinations $-9^{o} < \delta < +42^{o}$ in daily observations carried out on Large Phased Array (LPA). 31 new RRATs were discovered for dispersion measures (DM) from 2.5 to 72.6 pc cm^{-3} (посмотреть DM). Estimates of the periods were obtained for 9 RRATs. A convolutional neural network was used to select RRAT candidates. The study was carried out at the expense of a grant Russian Science Foundation 22-12-00236.

3-12 A serendipitous finding of a pulsar during monitoring of 3 magnetars

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Abstract: Magnetars are slowly rotating, highly magnetized young neutron stars that can show transient radio phenomena for radio pulses and fast radio bursts. We conducted radio observations of from two magnetars SGR J1935+2154 and 3XMM J185246.6+003317 and a high-magnetic field pulsar PSR J1846$-$0258 using the Five-hundred-meter Aperture Spherical radio Telescope (FAST). We performed single pulse and periodicity searches and did not detect radio signals from them. From the piggyback data recorded by other FAST telescope beams when we observed the magnetar SGR 1935+2154, we serendipitously discovered a new radio pulsar, PSR J1935+2200. We carried out the follow-up observations and obtained the timing solution based on these new observations and the archive FAST data. PSR J1935+2200 is an isolated old pulsar, with a spin period of 0.91s, a spin-period derivative of 9.19×10^{-15}~s~s^{-1}, and a characteristic age of 1.57 Myr. It is a weak pulsar with a flux density of 9.8 μJy at 1.25 GHz. Discovery of a new pulsar from the long FAST observations of 30 minutes implies that there may be more weak older pulsars in the Galactic disk to be discovered.

Session 4： Pulse measurements (Chairs：A. Philippov)

4-1 Polar explorers: emission beam studies of pulsars to FRBs

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Abstract:

4-2 Polarization profiles for 682 pulsars by FAST

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Abstract: Pulsar polarization profiles form a very basic database for understanding the emission processes in a pulsar magnetosphere. After polarization calibration of the 19-beam L-band receiver and verification of beam offset observation results, we obtain polarization profiles of 682 pulsars from observations by the Five-hundredmeter Aperture Spherical radio Telescope (FAST) during the Galactic Plane Pulsar Snapshot survey and other normal FAST projects. Among them, polarized pulse profiles and rotation measures of 460 pulsars are obtained for the first time. The profiles exhibit diverse features. Some pulsars have a polarization position angle curve with a S-shaped swing, some with orthogonal modes, some have components with highly linearly polarized components or strong circularly polarized components, some have a very wide profile, coming from an aligned rotator, and some have an interpulse from a perpendicular rotator, some wide profiles are caused by interstellar scattering. We derive geometric parameters for 190 pulsars from the S-shaped position angle curves. We find that the linear and circular polarization or the widths of pulse profiles have various frequency dependencies. Pulsars with a large fraction of linear polarization are more likely to have a large Edot.

4-3 Polarimetry for 56 millisecond pulsars in CPTA

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Abstract: We studied the polarization properties, frequency evolution, annual RM variations of 56 millisecond pulsars through data from Chinese Pulsar Timing Array (CPTA) observations. Due to the high sensitivity of FAST, we found a large number of details that have not been previously noted. In our data, some pulsars present weak components and weak bridge emission for the first time. This suggests that the emission region of the millisecond pulsar is more extended than previously thought. We found that there is a significant annual variation in RM of some pulsars, which may be due to the interaction between the solar wind and the Earth's ionosphere. In addition, we found that the polarization position angle curves of most millisecond pulsars could not be well fitted by the rotating vector model. However, we found that the sectional position angle curves of 15 pulsars matched the model prediction, indicating that there is still region in the pulsar magnetosphere dominated by dipolar

field. For most pulsars, there is no significant profile changes which illustrated the compact radiation regions of millisecond pulsars. While some pulsars exhibit a distinct evolution, which is caused by the different spectral indices of the sub-components of the pulses. We also found that orthogonal mode also have different spectral indices which cause the apparent evolution of linear polarization profiles. We detected that the circular polarization show sign reversal as function of frequency or pulse phases, which can help us understand the mechanism by which circular polarization occurs.

4-4 Average Profiles Classification and Beam Shape Studies

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Abstract: Pulsar radio emission originates around 50-100 stellar radii above the surface, with the plasma responsible for the emission formed due to sparking in an inner acceleration region above the polar cap. The radio emission originates from the region of the open dipolar magnetic field lines that can be broadly considered as an emission beam. The most widely accepted model of the average emission beam consists of a central core component surrounded by two concentric rings of conal components. We have found the average emission beam to show evolution with pulsar parameters, particularly rate of the rotational energy loss, dE/dt. The traditional model seems to be more more applicable for older pulsars with lower dE/dt. Deviation from the above emission beam model occurs for younger pulsars, in higher dE/dt range. Interestingly other emission features like subpulse drifting and degree of polarisation also show dependence on dE/dt.

Our aim is to establish the average emission beam of the pulsar population using the publicly available databases from telescopes like MEERKAT, FAST, Parkes, etc. We have compiled the largest dataset of fully polarised average profiles (approx. 1800 pulsars), over a wide frequency range between 100 MHz and 5 GHz. These studies covers detailed characterisation of the average profile properties like profile classification, measurement of the profile as well as individual components widths, estimating the line-of-sight geometry, etc. This will enable us to estimate the average emission beam and study their evolution with different parameters like observing frequency, dE/dt, etc.

4-5 To the statistics of radio pulsars

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Abstract: The data accumulated in recent years from the MeerKAT and FAST radio telescopes have made it possible to significantly increase the statistics of the

polarization properties of the average radiation profiles of radio pulsars. Using the procedure we developed earlier to determine orthogonal polarization modes, ordinary (O) and extraordinary (X), based on the analysis of the evolution of the positional angle and the degree of circular polarization, the widths of the average profiles were determined for each of the two modes. It was shown that the data from these reviews confirm a significant excess of the widths of the average mean profiles formed by the O-mode, which is consistent with theoretical ideas about the propagation of radio radiation in the magnetosphere of pulsars. In addition, the distributions of other observed pulsar characteristics were analyzed depending on the dominating radiation mode.

4-6 The profile characteristics of PSR J0953+0755

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Abstract: The pulsar PSR J0953+0755 is one of the brightest pulsars with extremely strong energy. In this talk, we contucted a study using 1 hour of data from FAST observations, focusing on profile properties, polarization characteristics.

4-7 Search for weak components in the radio emission of pulsars at a frequency of 110 MHz

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Abstract: According to the 10-year monitoring data, a search was conducted for weak components in the radio emission of pulsars observed on the Large Phased Array (LPI) radio telescope in the Pushchino Multibeam Pulsar Search (PUMPS). It was found that PSR J1543+0929 has radiation for almost the entire period. The profile has three-components with relative amplitudes of the conal components 0.013 and 0.026. For J2234+2114, a component was detected that is 200 ms away from the main pulse (MP).

As part of this program, the B0950+08 pulsar, which has low-level radiation outside the main pulse, was also studied. The intensity variations of three components in the emission of this pulsar were analyzed: the main pulse (MP), the interpulse (IP) and the bridge (M) between MP and IP. A high correlation was found between MP and IP amplitude variations both when averaged over 3.2 minutes and when averaged over years. This correlation is due to the refractive scintillation of the pulsar on the inhomogeneities of the interstellar plasma. The refractive scale of scintillation is about 2 days, and radiation modulation with a scale of 130 days was detected, which we associate with refraction. The frequency scale of diffraction scintillation for IP was measured and it was shown that the spectral shapes for MP and IP correlate well

and have the same frequency scale. The average amplitudes of MP, IP and M at a frequency of 110 MHz were determined: 23.7 Jy, 0.46 Jy and 0.24 Jy, respectively. Radiation occurs during at list 95% of the pulsar period.

The study was supported by the Russian Science Foundation, grant no. 22-12-00236, https://rscf.ru/project/22-12-00236

4-8 Detection of radio emission from three gamma-ray pulsars at the frequency 111 MHz

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Abstract: The detection and the investigation of radio emission from gamma-ray pulsars (J0357+3205, J1836+5925, J2043+2740) is reported. The observations have been made with LPA radio telescope at the Pushchino Radio Astronomy Observatory. Two pulsars (J0357+3205, J1836+5925) have been detected first time at the radio frequency band. Their common peculiarity is the rare events as the integrated pulses as well the individual ones. We defined the dispersion measured and obtained the estimations of the distance and the flux density. We presented also the integrated profiles.

This research supported by Russian Science Foundation grant no. 23-62-100043 and grant no. 22-12-00236.

4-9 Anomalous association between glitch and emission state in PSR J0742-2822

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Abstract: Glitches and the emission variations correspond to occasional catastrophic changes in the interior of the neutron star and alterations in the outer magnetosphere, respectively. Among all the known pulsars to have association between the emission variation and the glitch, the emission state changes soon after the glitch or a few seconds prior to the glitch. A widely accepted interpretation is that glitches can induce the change of pulsar magnetosphere and hence the emission. However, in this work we have identified the pre-glitch emission state change with 99.9992(3)% confidence for the first time by analyzing the archived observations of PSR J0742-2822 over the past 20 years. All 6 glitches in our observation occur during the four highly periodic (high-Q) states of W75. These states usually appear about 100 d (one oscillation of W75) before the latest glitch and, in general, do not change immediately after the glitch event. The phase-resolved analysis reveals that the opposite oscillations between the central and trailing parts of pulse profile causes the highly periodic oscillation of W75. These pre-glitch emission variations are not

expected in the framework of glitch-induced emission variations and challenge mainstream glitch models. In addition, glitches occurring ~100 d after emission state changes also suggest that the early warning of pulsar glitches is possible by monitoring the emission variability.

4-10 The uGMRT observations of sixteen gigahertz-peaked spectra pulsars candidates

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Abstract: Although 57 years have passed since the discovery of pulsars, we still lack a theory explaining the mechanism of radio emission that well describes the diversity of pulsar spectra. Among unusual pulsar spectra are those with the maximum intensity ~1 GHz (named gigahertz-peaked spectra). Recently we finished analysis of sixteen gigahertz-peaked spectra pulsars candidates observed using uGMRT wideband receivers at band-3 (250-500 MHz) and band-4 (550-850 MHz). One pulsar was missing in our interferometry maps, five pulsars were confirmed as GPS, one pulsar had broken spectrum, four pulsars had typical spectra described by simple power law function and four pulsars have probably turnovers below 500 MHz, but additional observations at low frequencies are needed to confirm it, also one pulsar has too scramble flux density measurements to be classified.

4-11 Spectral distribution of phase-resolved pulsar emission

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Abstract: In this talk, I will present a method to measure the morphological similarity of pulsar light curves and apply it to those recorded in the Third Fermi Pulsar Catalog. The method, based on dynamic time warping, produces a quantitative determination for the similiarity of time series, something that is usually only qualitatively discussed via light curve features (such as the number of peaks, their relative height and separation, the peak widths, etc.). Using such quantitative determination, it is possible to cluster the population into groups of pulsars with similar light curves and to explore the connection of these groups with respect to other pulsar features. The methodology is of general nature, and can be applied to light curves at different frequencies beyond gamma-rays, e.g., in radio or X-rays, to bursts, and also used with different aims, e.g., to analyze the similarity of mode changing between confirmed transitional pulsars and candidates.

2024-12-14：

Session 5： Single pulse (Chairs：David Smith)

5-1 A quantitative analysis of the similarity of pulsar light curves

Author: Diego F. Torres
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Abstract: In this talk, I will present a method to measure the morphological similarity of pulsar light curves and apply it to those recorded in the Third Fermi Pulsar Catalog. The method, based on dynamic time warping, produces a quantitative determination for the similiarity of time series, something that is usually only qualitatively discussed via light curve features (such as the number of peaks, their relative height and separation, the peak widths, etc.). Using such quantitative determination, it is possible to cluster the population into groups of pulsars with similar light curves and to explore the connection of these groups with respect to other pulsar features. The methodology is of general nature, and can be applied to light curves at different frequencies beyond gamma-rays, e.g., in radio or X-rays, to bursts, and also used with different aims, e.g., to analyze the similarity of mode changing between confirmed transitional pulsars and candidates.

5-2 Single-pulse study of CRAFTS pulsars discovered at FAST

Author: Rukiye Rejep
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Abstract: We present the single-pulse study of four CRAFTS pulsars discovered using FAST. We investigated the single-pulse phenomena and polarization information including subpulse modulation, nulling, as well as orthogonal polarization jumps for these pulsars. We discuss our findings and their implications for the magnetospheric physics and emission mechanisms.

5-3 Detailed emission analysis of three slow-period pulsars using FAST

Author: Habtamu M. Tedila
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Abstract: This study details the unique emission behaviors of three slow-period pulsars detected using the Five-hundred-meter Aperture Spherical Radio Telescope (FAST) during the Commensal Radio Astronomy FAST Survey (CRAFTS). These pulsars, PSR J1945+1221, PSR J2323+1214, and PSR J1900-0134, exhibited a quasi-periodic nulling phenomenon, with their emissions showing regular interruptions and the observed nulling duration lasting about 57 seconds. Among them, PSR J2323+1214 displayed a different nulling pattern, with the most extended nulling observed being 71.44 seconds. For the three pulsars, the nulling fractions ranged between 28\% and 57\%, with rotational periods from 1.83\,s to 4.75\,s. Differing

from the pulsars above, PSR J1900-0134 displayed complex emission features, and our high-resolution data revealed intricate microstructure pulses, with details down to a mere 1.57 microseconds. Bright pulses occur in all these sources with different occurrence rates. These observations suggest complex magnetospheric processes and provide insights into the origins of bright and microstructure pulses, as well as their distinctions from ordinary pulses. This research, leveraging the unparalleled sensitivity of FAST, deepens our understanding of the diverse emission behaviors in long-period pulsars.

5-4 Detailed Study of Two Pulsars J2053+4718 and J0021-0909

Author: YuTong Chen
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Abstract: J2053+4718 and J0021-0909 are two pulsars found by the Five-hundred-meter Aperture Spherical Radio Telescope (FAST). They were seperately observed by Parkes (J0021-0909, 2020) and Effelsberg (J2053+4718, 2021). Their ephemerides and average profiles were published earlier. Here we carried out detailed studies of these pulsars based on ~100min per each tracking observation on December 2023. We confirmed the properties showed in former researches and revealed more details such as nulling behavior, modulation and polarization properties. We also improved the ephemerides of these two pulsars and found them near the death lines predicted by several models in the p-pdot diagram. We believe that detailed studies of these near-death-line long-period pulsars could shed light on the pulsar emission mechanism and its temporal evolution in future observations.

5-5 PSR B0943+10: Mode Switch, Polar Cap Geometry, and Orthogonally Polarized Radiation

Author: ShunShun Cao
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Abstract: A study on PSR B0943+10's radiative/magnetospheric properties firstly based on FAST L band observation data is presented. The mode switch phenomenon of this pulsar is analyzed using a decomposition method, which reveals some profile evolution characteristics. After taking orthogonal polarization modes (OPMs) into account, we derive B0943+10's radiation geometry (alpha=42deg, beta=14deg) through RVM fitting. We suggest that under this geometry, the X-ray emission modulation of the pulsar is easily understood, and the differences between the main pulse's and the precursor component's radiative processes may explain the X-ray's synchronization with radio mode switch. Single pulses' polarization investigation is also carried out, showing different OPM proportions in different radiation modes as well as different handedness and magnitudes of circular polarization in different

OPMs. The results could be related to certain propagation effects in the pulsar magnetosphere.

5-6 Diverse individual pulses revealed by FAST

Author: Yi Yan
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Abstract: Based on super-sensitive observations of pulsars at the L-band by the Five-hundred-meter Aperture Spherical radio Telescope (FAST), we analyse the single pulse sequences for FAST-detected pulsars, and find that 118 pulsars show nulling, mode changing or modulation phenomena. Among them, nulling phenomenon is detected for 59 pulsars; the emission mode changes are detected for 18 pulsars; the modulation as well as subpulse driftings are observed from 80 pulsars. Some behaviors of 101 pulsars are detected the first time. Two or more individual phenomena have been detected for 33 pulsars.

5-7 Dwarf pulses revealed by FAST

Author: Chen Wang
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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.

5-8 Microstructures detected by FAST

Author: Tao Wang
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Abstract: Micro-structures (or micro-pulses) are the key to revealing the extreme magnetospheric conditions in pulsars that have puzzled researchers for decades. In general, they are characterized by their narrow widths. Additionally, some micro-structures exhibit quasi-periodic and stable oscillations in intensity, revealing a type of periodic modulation in the relativistic plasma within the magnetosphere. FAST's high detection sensitivity and time resolution are well-suited for searching for these phenomena. Based on the data from the FAST Galactic Plane Pulsar Snapshot (GPPS) survey and the published FAST data, we have developed an automatic search technique for quasi-periodic micro-structures and micro-pulses. As a result, we have identified 47 new pulsars with quasi-periodic micro-structures, finding that quasi-periodic micro-structures are indeed a common phenomenon in pulsars. Moreover, for the first time, we detected quasi-periodic micro-structures in both the main and interpulses of PSR J1932+1059. The typical quasi-periodicities of the main and interpulses are the same, suggesting similar plasma conditions in the polar cap. A tremendous number of micro-pulses have been detected in 40 pulsars. No linear correlation was found between the typical width of micro-pulses and the rotation periods of those pulsars. Furthermore, a more detailed analysis of the polarization characteristics of individual micro-pulses could help uncover the mysteries of pulsar radiation and propagation processes.

5-9 Quasi-periodic micro-structure: A unifying feature for all radio-emitting neutron stars?

Author: Kuo Liu
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Abstract: Highly concentrated and repeating busty radio emission has been observed in pulsars soon after their discovery, commonly known as micro-structure. This intriguing phenomenon has been studied in detail within the group of canonical pulsars for decades. In this talk, I will report on the most recent progress on reseaching into pulsar micro-structure emission. Thanks to the significant advance in data acquisition system in the past years, this phenomenon is now seen in all classes of rotation-powered neutron stars, magnetars, and even some of the fast radio bursts (FRBs). These findings suggest a common emission mechanism behind the scenes, and may provide an important link between rotating neutron stars and FRBs.

Session 6： Emission mechanism-1 (Chairs：Dong Lai)

6-1 Magnetospheric structure and broadband emission in pulsars

Author: Anatoly Spitkovsky
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Abstract: I will discuss the global modeling of pulsar magnetospheres in different plasma supply regimes, emphasizing the formation and loading of equatorial current sheet with plasma. The sheet turns out to be important for acceleration of particles that produce both incoherent high-energy and coherent (giant-pulse-like) radio emission. Other regions of particle acceleration, such as the polar gaps, are responsible for regular radio emission, which now appears in resolved simulations. I will highlight recent developments in multidimensional cascade modeling and the interaction of the polar cascade with time-dependent phenomena in the closed zone. Ab-initio models of pulsar magnetospheres are starting to explain the observed features of multi-wavelength emission of pulsars.

6-2 Pair Production in Pulsar Magnetosphere

Author: Andrey Timokhin
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Abstract: The creation of electron-positron pairs plays a critical role in forming pulsar magnetospheres. In recent years significant progress has been achieved in self-consistent modeling of pair creation in pulsars. In this talk, I will provide a brief overview of our current understanding of where and how pair formation operates in magnetospheres of pulsars, how much pair plasma is produced, and what the implications are for pulsar emission mechanisms and the physics of pulsar wind nebulae.

6-3 Signatures of radiative processes in radio pulse profiles.

Author: Jaroslaw Dyks
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Abstract: I will present observational evidence for the inverse Compton scattering (ICS) of curvature radiation (CR) in the pulsar magnetosphere.

The scattering in dipolar magnetosphere occurs at a universal-like angle which facilitates the appearance of a nested cone beam, with the cone size ratio that is consistent with the observed profiles.

Moreover, the ICS of CR allows us to understand the specific shape of the outstanding bifurcated precursor observed in the millisecond pulsar J1012+5307. The shallow outer wings and the excessive size of this feature can be explained by the Doppler shift and the spectral convolution involved in the ICS.

6-4 Synchro-curvature modelling of lightcurves and spectra of pulsars

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Abstract: The detected high-energy pulsar population is numerous, and thus, having agile and physically relevant codes to analyze it consistently is important to gather information of its global behavior. In this talk, we present new relevant capabilities of a radiative model that computes the dynamics of charged particles traveling in the pulsar's magnetosphere, and calculates their spectral emission via synchro-curvature radiation losses. The model aims at explaining the high-energy emission of all pulsars in an effective way, relying on just three parameters, and has succeeded in fitting the gamma-ray spectra of the whole population of gamma-ray pulsars and reproduces well those pulsars that also have detected non-thermal X-ray pulsations. On the one hand, we have incorporated a better treatment of the particle injection, including a distributed injection zone. We have also incorporated a fast and accurate minimization technique, allowing to obtain proper spectral fittings with a large improvement in computational cost, critical for population studies. On the other hand, by establishing a new, detailed description of magnetic field lines and their geometry, including torsion (relevant where toroidal components of the magnetic field are of note, e.g. at the Y-point), we are able to analyze both spectral and light curves simultaneously, computing synchro-curvature emission and particle distribution sky maps. This allows us to analyze global statistics for pulsar detectability, as well as the appearance of peaks of multi-peaks in the pulsar light curves. The sample of theoretical light curves created presents very similar features to the zoo of observational gamma-ray light curves of pulsars, in terms of morphology, number of peaks and widths of the peaks. We find a general agreement in global properties with several main conclusions: Among them 1) that the detection probability due to beaming is much higher for orthogonal rotators (approaching 100 per cent) than for small inclination angles (less than 20 per cent). 2) that the small variation in the synthetic skymaps generated for different pulsars indicates that the geometry dominates over timing and spectral properties in shaping the gamma-ray light curves 3) The global observed statistics of the light curves follow the same trend as that obtained from single pulsars when considering all the light curves it can in principle produce.

6-5 Investigating coherent radio emissions from pulsar polar caps by particle-in-cell kinetic simulation

Author: Jan Benáček
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Abstract: Coherent radio waves from pulsars bring information about relativistic extremely-magnetized pair plasmas in neutron star magnetospheres because the waves originate at plasma kinetic scales. Though various radio emission mechanisms have been proposed in the last decades for their interpretation, many lack the inclusion of self-consistent wave-wave and particle-wave interactions, emission

power, spectrum, polarization properties, and directivity that are necessary for interpreting the observations. Hence, particle-in-cell (PIC) kinetic simulations that self-consistently include the necessary effects are an excellent tool for plasma and radio emission diagnostics.
We carried out 2D and 3D PIC simulations that included pair-creation cascades in pulsar polar caps by curvature radiation. We studied a range of magnetic dipole inclination angles and magnetospheric currents to reveal how radio emissions can operate for various structures of pulsar magnetospheres and what the radiation polarization properties are.
We found that the pair-creation events produce intensive Poynting flux originating in an electric gap region close to the star surface, and that the Poynting flux escapes the polar cap along open field lines where the plasma density is low, and the flux may propagate without significant absorption. Our results indicate that no energy conversion process from particles to waves may be necessary for pulsar coherent radio emissions—the pulsar emission is directly produced by electromagnetic waves that escape the oscillating polar gap. The produced pulsar radio beam does not have a cone structure; instead, the radiation mostly escapes along those open magnetic field lines in which no pair creation occurs. Moreover, the radiation is typically strongly linearly polarized in the normal direction to the edge of the Poynting flux channel, following the rotating vector model for certain observer positions.

6-6 Kinetic simulations of pulsar magnetosphere interacting with a companion wind

Author: YiCi Zhong
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Abstract: In binary systems with strong companion winds, pulsars can have the magnetopause separating their magnetosphere from the wind located well within their light cylinder. This bow-shaped enclosure functions as a waveguide that confines the pulsar's electromagnetic fields and can significantly alter its spindown. Using particle-in-cell simulations, we investigate the spindown of pulsars with such confined magnetospheres, characterized by the ratio of the equatorial standoff distance R_m to the pulsar's light cylinder R_LC. We find that, in strongly confined models ($R_\mathrm{m}/R_\mathrm{LC} = 1/3$) , the spindown of an aligned pulsar is enhanced threefold due to the increased number of open magnetic field lines. Conversely, for an orthogonal pulsar, the spindown is suppressed due to a mismatch between the pulsar wind stripe wavelength and the waveguide size. Applying our analysis to the 2.77-second oblique rotator PSR-B ($\chi \sim 60^\circ$) in the double pulsar system PSR J0737-3039, we constrain its surface magnetic field to $B_* \approx (7.3 \pm 0.2) \times 10^{11}$ G. Our calculations yield a lower bound for the braking index of PSR-B, $n = 2.56$, and an upper limit for modulation in the observed period derivative, ${|\Delta \dot{P}_\mathrm{B}|}/{\dot{P}_\mathrm{B}} \sim 4 \%$. We speculate that the toroidal twist in strongly compressed magnetospheres with

$R_\mathrm{m}/R_\mathrm{LC}=1/3$ can increase the plasma multiplicity in the closed zone of PSR-B and thereby produce the observed radio eclipse.

6-7 The enigma of nulling: the novel statistics of pulsars' dying breaths

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Abstract: The phenomenon of pulsar nulling, where pulsars temporarily and stochastically cease their radio emission, is thought to be indicative of a `dying' pulsar, where radio emission ceases entirely. We recently discovered a quasi-periodically nulling pulsar (reported in Grover et al. 2024), which led us to explore other similar pulsars in the literature that show both sub-pulse drifting and quasi-periodic nulling. Our analysis shows clear evidence for quasi-periodically nulling pulsars located in the pulsar death valley, following a similar gradient to those of currently theorised pulsar death lines. However, this is based on a collection of measurements currently available in the literature rather than from a singular cohesive study. We have hence undertaken an extensive analysis of long-period and nulling pulsars using data sets from the ongoing SMART survey to characterise nulling using novel approaches. Previous methods of characterising nulling tend to fail at low S/N as the summation of ‘nulling’ pulses indicates uncharacterised, low-level emission via an integrated profile. We propose a new method that involves summing random pairs of pulses together and utilising probability trees, Gaussian mixture modelling and MCMC to robustly estimate nulling fractions. This method offers the benefit that it does not require a large number of pulses to obtain robust estimates of nulling characteristics, it can utilise low S/N pulses, and the results from this new approach can hence be used to investigate potential links between pulsar rotation periods and nulling properties, and to understand the quasi-periodically nulling population on the PPdot diagram and its implications for the pulsar death lines and radio emission mechanism.

6-8 Magnetic-field oscillation model of pulsar

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Abstract: Since the discovery of pulsars, the rotating-lighthouse model has been the only model to explain pulsar radiation. After discovering that some white dwarfs (e.g. AR Scorpii), main sequence stars (e.g. CU Virginis), and ultracold dwarfs (e.g. TVLM 513−46546) can also generate radio pulses, the lighthouse model was once again used to explain their pulse signals. However, our research found that using a magnetic field oscillation model (MO model) can better explain all pulse radiation and requires fewer assumptions.

One basic prediction of our MO model is that there is a 90 degree phase lag between pulsed radiation and magnetic field oscillations. The radio pulses and

magnetic field data observed from several main sequence stars and ultracold dwarfs perfectly confirm our prediction, and so far, there have been no exceptions.

The magnetic fields of main sequence stars and ultracold dwarfs samples that emit radio pulses have been measured. Its magnetic field strength is only a few thousand Gauss. Such a low magnetic field can also generate radio pulses, which should prompt us to reconsider the radiation mechanism of pulsars from the start point.

Since neutron stars, white dwarfs, main sequence stars, and ultracold dwarfs can all emit pulse signals, we suggest studying them as a whole and dividing them into four categories based on their periods:

1. Hour pulsar (non-compact star).
2. Minute pulsar (white dwarf).
3. Second pulsar (neutron star).
4. Millisecond pulsar (recycled pulsar).

6-9 Will the magnetic field of a pulsar co-rotate with the neutron star?

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Abstract: At present, the rotating-lighthouse model is the only model to explain the pulsar pulse radiation. One basic assumption of this model is that the magnetic field of a pulsar follows the rotation of a neutron star. However, when a magnet rotates around its own magnetic axis, whether its magnetic field co-rotates with it is an ancient and unresolved question. By searching with the keywords 'unipolar induction' or 'homopolar induction', a large number of relevant literature can be found. Most of these documents conclude that the magnetic field does not rotate along with the magnet. This is also the viewpoint of Faraday, Feynman, and Alfven. Feynman once said, "Therefore, it makes no sense to say something like: When I move a magnet, it takes its field with it, so the lines of B are also moved." (Lectures on physics, Section 13-6). Alfven once said, " ... whether the magnetic lines of force from a rotating magnet rotate with the magnet or not. The result was that it has no meaning to speak about the 'motion' of a magnetic field." (Cosmical electrodynamics, Section 1.3.2). This also means that it is meaningless to say that the magnetic field of a pulsar co-rotates with the star.

Since Faraday, Feynman, and Alfven all proposed that magnetic fields do not move with magnets, why do astrophysicists generally hold the opposite view? In this symposium, we will discuss this issue and demonstrate our understanding of it through video animation. Especially explain: how to deal with the "motion" of the magnetic field when the magnetic inclination is not equal to zero (such as the Earth's magnetic field).

We suggest that the pulsar community reconsider this fundamental issue. This question is also the foundation of our magnetic field oscillation model.

Session 7： FRBs and telescope key projects (Chairs： WeiWei Zhu)

7-1 Pulsar science with MeerKAT

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Abstract: The extraordinary sensitivity of the MeerkAT telescope has, in only a few years, led to much progres and many discoveries in the field of radio pulsars. In this talk I will describe the two MeerKAT Large Survey Projects on pulsars, MeerTime and TRAPUM, reporting some of the most interesting results both from pulsar searches and timing studies.

7-2 LOFAR 2.0 and Its Prospects in Pulsar Science

Author: Jun Wang
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Abstract: LOFAR 2.0 represents a significant upgrade to the original LOFAR system, enhancing its sensitivity, bandwidth, and real-time processing capabilities. These improvements hold substantial promise for pulsar science, enabling more precise measurements of pulsar timing, rotation, and emission properties. The system’s advanced real-time monitoring and data handling also support larger and deeper pulsar surveys, potentially leading to the discovery of new pulsar populations. Moreover, LOFAR 2.0's integration with other next-generation facilities may allow for unprecedented studies of gravitational waves, neutron star interiors, and pulsar timing arrays. These developments position LOFAR 2.0 as a critical tool in advancing our understanding of pulsars and their role in fundamental physics.

7-3 Modeling the Radial Distribution of Pulsars in the Galaxy

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Abstract: we have explored the spatial distribution and birth rate of normal pulsars. The pulsar distances used to calculate the pulsar urface density are estimated from the YMW16 electron-density model. When estimating the impact of the Galactic background radiation on our survey, we projected pulsars in the galaxy onto the Galactic plane, assuming that the flux density distribution of pulsars is uniform in all directions, and utilized the most up-to-date background temperature map. We also used an up-to-date version of the ATNF Pulsar Catalogue to model the distribution of

pulsar flux densities at 1400 MHz. We derive an improved radial distribution for the pulsar surface density projected onto the Galactic plane.

7-4 Structure, oscillations and gravitational wave of hybrid quark stars

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Abstract: Due to the dense environment, quark matter is probably emerge in compact stars, e.g. the cold neutron stars, the hot proto-neutron stars or the remnant of two neutron star merger. At present, it is quite important to look for possible observational signals to distinguish the hybrid stars from normal neutron stars. Concern the recent development in gravitational wave observation, we investigate radial and non-radial oscillations of pure and hybrid neutron stars, employing equations of state of nuclear matter from Brueckner-Hartree-Fock theory, and of quark matter from the Dyson-Schwinger quark model, performing a Gibbs construction for the mixed phase in hybrid stars. For radial oscillations, our results for the zero points of the first-order radial oscillation frequencies give the maximum mass of stable neutron stars, consistent with the common criterion $dM/d\rho c = 0$. For non-radial oscillations, characteristic differences between neutron-star and hybrid-star g1-mode oscillation frequencies, damping times, and gravitational wave strains are pointed out. Temperature effects in proto-neutron stars and effects of pasta-structure in the phase transition are also discussed.

7-5 6.5-year monitoring programs on a special FRB repeater

Author: Rui Luo
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Abstract: Fast Radio Bursts (FRBs) are enigmatic short-duration radio flashes in the universe. According to the repetition of some FRB sources, we can study their various and intriguing properties directly through monitoring observations with sensitive radio telescopes. In this talk, I will present the key results of our long-term monitoring programs on the repeating FRB source – FRB 20180301A. We have been using multiple radio telescopes in the world to observe this repeater for 6.5 years, depicting its dynamic environment by revealing its secular evolution yearly. The trends of DM/RM variations are essential to unravel the mystery of FRB progenitor.

7-6 Magnetospheric origin of FRBs

Author: WeiYang Wang
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Abstract: Coherent curvature radiation as the radiation mechanism for fast radio bursts (FRBs) has been discussed since FRBs were discovered. We study the spectral and polarization properties of repeating FRBs within the framework of coherent curvature radiation by charged bunches in the magnetosphere of a highly magnetized neutron star. The spectra can be generally characterized by multisegment broken power laws, and evolve as bunches move and the line of sight sweeps. Emitted waves are highly linear polarized if the line of sight is confined to the beam within an angle of $1/\gamma$, while circular polarized degree becomes strong for off-beam cases. The spectro-temporal pulse-to-pulse properties can be a natural consequence due to the magnetospheric geometry. We investigate the relationship between drift rate, central frequency and their temporal duration. The radius-to-frequency mapping is derived and simulated within the assumptions of both dipolar and quadrupolar magnetic configurations. The geometric results show that FRBs are emitted in field lines more curved than open field lines for a dipolar geometry. This suggests that there are most likely existing multipolar magnetic configurations in the emission region.

7-7 Rotation Measure Variations of Repeating FRBs in Binary Systems

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Abstract: Recent observations discovered that some repeating fast radio bursts (FRBs) show complicated variations and reversals of Faraday rotation measures (RMs), indicating that the sources of these FRBs are embedded in a dynamically magnetized environment. One possible scenario is that repeating FRBs are generated by pulsars in binary systems, especially containing a high-mass companion with strong stellar outflows. Here we study the RM variations caused by stellar winds and a possible stellar disk. Our model can explain the evolution of RM for some active repeating FRBs, such as FRB 20201124A, FRB 20190520B and FRB 20180916B.

7-8 Polarization position Angle jump of FRB 20201124A

Author: JiaRui Niu
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Abstract: This talk is about the first detection of polarization angle (PA) orthogonal jumps from a fast radio burst (FRB) source FRB 20201124A. We find three cases of orthogonal jumps in over two thousand bursts, all resembling those observed in pulsar single pulses. This discovery provides convincing evidence that FRB emission originates from the complex magnetosphere of a magnetar.

7-9 Hyper-active repeating fast radio bursts from rotation modulated starquakes on magnetars

Author: JiaWei Luo
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Abstract: Fast radio bursts (FRBs) are short, energetic cosmic radio transients whose origin remains unresolved. Intriguingly, repeated bursts are observed from some FRB sources, while others do not present such repetition. Moreover, bimodal distributions of waiting time are observed in some hyper-active FRBs, a significant deviation from the exponential distribution expected from stationary Poisson processes. By combining the epidemic-type aftershock sequence (ETAS) earthquake model and the rotating vector model (RVM) involving the orientations of the spin axis, the magnetic axis, and the rotation of the magnetar, we find that starquake events modulated by the rotation of FRB-emitting magnetar can explain the bimodal distribution of FRB waiting time, as well as the non-detection of periodicity in active repeating FRBs. We analyze data from multiple FRB sources, demonstrating that differences in waiting time distributions and observed energies can be explained by varying parameters related to the magnetar's properties and starquake dynamics. Our results suggest that rotation-modulated starquakes on magnetars can possibly be a unified source of FRBs.

7-10 A 44-minute periodic radio transient in a supernova remnant

Author: Mao Yuan
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Abstract: Long-period radio transients (LPTs) are a newly discovered class of radio emitters with yet incomprehensibly long rotation periods, ranging from minutes to hours. The astrophysical nature of their isolated counterparts remains undetermined. We report a new LPT, DART J1832-0911 (2656.23±0.15 s period), the first evidence associating such objects to supernova remnants (SNRs). Its dispersion measure distance aligns well with the distance of the SNR, confirming its origin from a supernova explosion. The source displays either phase-locked circularly polarized emission or nearly 100% linear polarization in radio bands. No detectable optical counterpart was found, even with a 10m-class telescope. The J1832-0911's SNR association, stable, highly polarized emission, and abnormally long period strongly favor its origin from a young neutron star, whose spin has been braked, possibly by interaction with supernova's fallback materials. This discovery provides critical insights into the nature of ultra-long period transients and their evolutionary link to stellar remnants.

Session 8： Pulsars timing and binaries (Chairs：KeJia Lee)

8-1 X-ray pulsars observed by Insight-HXMT and NICER

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Abstract: This talk presents a systematic investigation into the long-term evolutionary characteristics of high-energy radiation from pulsars, utilizing all available observations from Insight-HXMT as well as data from other high-energy telescopes, such as NICER and Fermi-LAT. More research progress has been made in the areas of phase-resolved spectra of pulsars, state transition studies, and statistical analyses of glitches. For the Crab pulsar, more detailed phase-resolved spectra have been obtained from Insight-HXMT observations. Notably, the X-ray emission remains unchanged following a significant glitch in the Crab pulsar, while a delayed spin-up component has been identified in two other larger glitches. Additionally, we discovered the second young pulsar, J1124-5916, exhibiting a state transition. A systematic study of glitches in Vela-like pulsars has also been conducted. In the realm of magnetars and fast radio bursts, a comprehensive series of observations and analyses focused on the first magnetar, SGR J1935+2154, which is associated with fast radio bursts, including a quasi-periodic oscillation tied to FRB 200428. Finally, we have detected anti-glitches in normal pulsars, such as PSR B0540-69 and PSR J1522-5735.

8-2 Timing of Newly Discovered Pulsars from the FAST Galactic Plane Pulsar Snapshot Survey

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Abstract: Timing observations are crucial for determining the basic parameters and properties of newly discovered pulsars. Using the Five-hundred-meter Aperture Spherical Radio Telescope (FAST) with its L-band 19-beam receiver, the FAST Galactic Plane Pulsar Snapshot (GPPS) Survey has discovered 751 pulsars. Using both targeted follow-up observations and coincidental survey data, we obtained timing solutions for 30 new isolated pulsars, and Keplerian parameters for 112 newly discovered binary pulsars, with timing solutions for 36 of these binary pulsars. The companions of new binary pulsars are He white dwarfs, CO/ONe white dwarfs, neutron stars, main sequence stars and ultra light objects or even planets. For compact binary systems, we measured Shapiro delays for 4 pulsars with massive white dwarf companions and periastron advances for 3 double neutron star systems, allowing us to constrain the masses of the pulsars and their companions.

8-3 The timing and spectral properties of the 2022 outburst of SGR J1935+2154 observed with NICER

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Abstract: The magnetar SGR J1935+2154 entered a new active episode on October 12, 2022, with the detection of many X-ray bursts and the enhancement of its persistent emission. Radio bursts were also detected at the tail of the burst forest, revealing the connection between the properties of X-ray activities and the radio emission. We analyzed observations of SGR J1935+2154 for nearly three months, using data from the Neutron Star Interior Composition Explorer (NICER). We report the timing and spectral results of the X-ray persistent emission following the onset of this outburst. During the decay of the outburst, a flare is evident on the light curve, resulting in about one order of magnitude increase in unabsorbed flux. A fast radio burst was detected immediately following the peak of this flare. We found a phase jump of the single-peaked pulse profile, with a deviation of 0.16 ± 0.03 phase, which is related to the glitch. And the time of the phase jump is slightly earlier than the peak of the flare. The spectral result indicates that the photon index of the power law is inversely correlated with both the unabsorbed flux and the burst rate. The phase-resolved spectral result further supports the results of the phase jump. These results manifest the connection between the glitch, phase jump, burst forest, and radio burst, which is crucial for studying the mutation in twisted magnetic fields and constraining the trigger mechanism of radio bursts.

8-4 Compact Binary Millisecond Pulsars and the Growing Spider Web

Author: Manuel Linares
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Abstract: A new population of neutron stars has emerged in our Galaxy during the last 15 years: compact binary millisecond pulsars, also known as "spiders". I will review the neutron star mass distribution in light of this growing spider population, focusing on the most massive neutron stars.

8-5 Formation of binary millisecond pulsars and ultracompact X-ray binaries

Author: WenCong Chen
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Abstract: It is generally thought that binary millisecond pulsars (BMSPs) evolve from low-mass X-ray binaries (LMXBs) via an accretion of mass and angular momentum. During the evolution of LMXBs, the magnetic braking (MB) mechanism plays a vital role in driving the mass transfer and orbital evolution. However, the predicted mass-transfer rates by the standard MB model are at least an order of magnitude lower than the observations in some LMXBs with short orbital periods. In this talk, we discuss the advantage and shortcoming of other MB prescriptions in modeling the formation and evolution of different binary systems including BMSPs and ultracompact X-ray

binaries. Furthermore, we also discuss the influence of irradiation effect of X-ray on the formation of BMSPs.

8-6 Formation and evolution of ultracompact X-ray binaries with WD donors

Author: HaiLiang Chen
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Abstract: Ultracompact X-ray binaries (UCXBs) are X-ray binaries with short orbital periods (Porb < 80 min). The accretors are neutron stars (NSs) or black holes (BHs) and the companion stars are hydrogen-deficient, partially or fully degenerate low-mass (< 0.2 M) stars. UCXBs are important for studies of binary evolution, accretion disks and accreting millisecond pulsars. They are also very important sources for gravitational wave (GW) detectors, such as LISA, TianQin, and Taiji. In this talk, I will discuss the fine-tuning problem of formation of UCXBs, the stability of mass transfer of NS+WD binaries, properties of UCXBs as GW sources and formation of BH-UCXBs via accretion induced collapse of Nss.

8-7 Formation of black widows through ultracompact X-ray binaries with He star companions

Author: YunLang Guo
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Abstract: Black widows (BWs) are a type of eclipsing MSPs with companion mass (M_2) < 0.05 M_sun. Recent observations indicate that there are two subtypes of BWs. One is the BWs with M_2 ~ 0.01-0.05 M_sun, whereas another with M_2 < 0.01M_sun. However, the origin of the latter is still highly uncertain. In this work, we further considered the evaporation based on the UCXBs with He star donor channel. Our channel can explain the formation of the BWs with M_2 < 0.01M_sun. In addition, the companion mass can decrease to < 0.001M_sun or even < 10^(-5) M_sun within the Hubble time. This means that the companion will undergo the tidal disruption, leading to that the pulsar binary leave behind an isolated MSP eventually. Thus, the BWs formed by this channel are the potential progenitors of isolated MSPs.

8-8 An eclipsed millisecond pulsar in a highly compact binary

Author: Zonglin Yang
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Abstract: A binary system of a mildly recycled pulsar with a helium star in a very compact orbit ought to be produced after the envelope of the companion star is ejected, but such a system is too rare to detect because of its short lifetime and low

birthrate. We report the discovery of a compact binary system with an orbital period of 3.60 hours, which consists of a pulsar J1928+1815 with a spin period of 10.55 ms and an undetected companion with a mass of 1.0 – 1.6 M⊙, most probably a helium star, that eclipses pulsar signals for about 17% of orbit. This system should be a smoking gun for the common envelope phase for the formation of compact binary systems discussed for decades.

8-9 Is the peculiar velocity of the compact star in Cygnus X-3 related to it being a neutron star?

Author: Jeongsook Kim
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Abstract: The Cygnus X-3 binary system, classified as a high-mass X-ray binary (HMXB), consists of a Wolf-Rayet (WR) star and an unidentified compact object with an orbital period of 4.8 hours. This system is considered a potential precursor to a double compact system, particularly following the supernova explosion of the WR star. The compact star could form either a neutron star (NS) or a black hole (BH).

If the compact star is a black hole, it likely formed via core-collapse or accretion-induced collapse of a neutron star, processes associated with low kick velocities (< 50 km/s). However, we conducted astrometric Very Long Baseline Interferometry (VLBI) observations of Cygnus X-3 using the KVN and VERA Array (KaVA) from 2020 to 2021, determining the astrometric position of its core. Our analysis incorporated archival data from approximately 40 years of observations by the Very Large Array (VLA), Very Long Baseline Array (VLBA), European VLBI Network (EVN), and the East Asian VLBI Network (EAVN). By estimating the system's proper motion, we constrained its peculiar velocity in the context of three-dimensional Galactic motion, indicating a velocity exceeding 100 km/s with a 1σ error.

This high velocity suggests that the compact star in Cygnus X-3 likely received a significant natal kick, potentially due to a supernova explosion rather than a direct collapse. We present the possibility that the compact star in Cygnus X-3 could be a neutron star by comparing the relationship between the short orbital period and peculiar velocity with other HMXB systems containing neutron stars.

8-10 Assessing the complexity of orbital parameters after asymmetric kick in binary pulsars

Author: Ali Taani
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Abstract: The dynamical characterization of the Millisecond Pulsar (MSP) parameters is a key issue in understanding these systems. We present an analytical analysis of the orbital parameters of binary MSPs with long periods (d) and circular (e≤ 0.1) orbits,

produced by an asymmetric kick model imparted during the Accretion Induced Collapse (AIC) of white dwarfs process. It turns out that the distribution of orbits peaks up to 90 d with strong circularization. Considering the different assumptions about the distribution of companion He stars , the binary will affect the setups of the balance condition of minimum energy. Our analytical approach is just a first approach to the more complete models required for describing all binary parameters after an asymmetric kick. Therefore, we have also run some numerical simulations in order to compare their results with the analytical studies. We aim to initiate a first exploration of the full complexity of the problem, when combining a variable kick time and a variable kick vector direction. Indeed, the numerical simulations show patterns resembling the complex behavior found in chaotic scattering problems. Although we deal with a deterministic problem and bounded orbits, the regular characteristic orbits are found in more realistic phases during the AIC process. In addition, the overall process can show complex behaviors strongly associated with the internal kick mechanisms. This would lead us to identify the nature of regular orbits and their orbital morphology.

8-11 Measuring glitch recoveries and braking indices with Bayesian model selection

Author: Yang Liu
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Abstract: For a selection of 35 pulsars with large spin-up glitches ($\Delta{\nu}/\nu\geq10^{-6}$), which are monitored by the Jodrell Bank Observatory, we analyse 157 glitches and their recoveries. All parameters are measured consistently and we choose the best model to describe the post-glitch recovery based on Bayesian evidence. We present updated glitch epochs, sizes, changes of spin down rate, exponentially recovering components (amplitude and corresponding timescale) when present, as well as pulsars' second frequency derivatives and their glitch associated changes if detected. We discuss the different observed styles of post-glitch recovery as well as some particularly interesting sources. Several correlations are revealed between glitch parameters and pulsar spin parameters, including a very strong correlation between a pulsar's interglitch $|\ddot{\nu}|$ and $\dot{\nu}$, as well as between the glitch-induced spin-down rate change $\Delta\dot{\nu}_{\rm p}$ that does not relax exponentially and $\dot{\nu}$. We find that the ratio $\left|\Delta \dot{\nu}_{\mathrm{p}}/\ddot{\nu}\right|$ can be used as an estimate of glitch recurrence times, especially for those pulsars for which there are indications of a characteristic glitch size and interglitch waiting time. We calculate the interglitch braking index n and find that pulsars with large glitches typically have n greater than 3, suggesting that internal torques dominate the rotational evolution between glitches. The external torque, e.g. from electromagnetic dipole radiation, could dominate the observed $\ddot{\nu}$ for the youngest pulsars ($\lesssim10^{4}\;\mathrm{yr}$), which may be expected to display $n\sim3$.

8-12 The lightest NS known found in a new DNS candidate
Author: Christine Kazantsev
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Abstract: We will present a new mildly recycled radio pulsar in a 2-day eccentric binary system. Timing observations carried out with the Arecibo and FAST telescopes over the past several years have led to the detection of relativistic effects, enabling mass measurements for both objects. While the orbital properties of this system are similar to other known double-neutron-star systems (DNSs) in the Galactic field, the very low mass of the companion challenges both our understanding of neutron-star formation and binary evolution. Potential scenarios for the system formation will be discussed. Confirming the nature of the companion would require the detection of a multi-wavelength counterpart with sensitive instruments such as XMM and Einstein Probe.

8-13 Fundamental Physics with Pulsars in the Galactic Centre
Author: Lijing Shao
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Abstract: In this talk I will present our recent work on using radio timing of pulsars in the Galactic centre region, and the newly proposed strategies of using them to test gravity theories and dark matter properties that other means cannot effectively probe.

2024-12-15：

Session 9：Special FAST session （Chairs：RenXin Xu）

9-1 FAST status and upgrade plan
Author: WeiWei Zhu
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Abstract: I will introduce the operating status, future upgrade plans for the FAST telescope, and some recent pulsar and FRB-related works.

9-2 An overview of pulsars and FRBs survey from CRAFTS
Author: Pei Wang
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Abstract: The radiative mechanism of pulsars and the origin of Fast Radio Bursts (FRBs) are unknown and are currently major astrophysical puzzles. The study of pulsars and FRBs is a frontier field for the Commensal Radio Astronomy FAST survey (CRAFTS), offering significant opportunities for breakthroughs in fundamental physics and astronomy. The CRAFTS has so far covered 21% of the FAST sky and discovered around 200 new pulsars and 8 FRB sources, including about 40 MSPs, 3 double neutron star systems, ~35 RRATs, and a persistently active repeating FRB. The presentation will focus on the recent observational progress and discoveries made using CRAFTS. By exploring the dynamic Universe with CRAFTS, it may expand the horizon of this new active frontier of radio astronomy.

9-3 On the significant pulsar science targets of FAST telescope

Author: ChengMin Zhang
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Abstract: Five hundred meter Aperture Spherical Radio Telescope (FAST) is currently the world's largest and most sensitive single dish, which has discovered about one thousand new pulsars so far, expanding the pulsar database to about 4000 samples. FAST has the potential to discover 5000 pulsars, and the expected special types of samples to be discovered include, pulsar + black hole binary system, double millisecond pulsars, sub-millisecond, long-period, emission fine structure of pulsar, unique pulsars with multiple energy bands (e.g., FERMI gamma pulsars, magnetars and accreting neutron stars with radio emissions, etc.), verifying general relativity and gravitational waves in high precision, as well as the Pulsar Timing Array (PTA). Furthermore, the study of the correlation between extragalactic pulsars and fast radio bursts is currently under consideration.

9-4 55 Years of Pulsar Research

Author: Dick Manchester
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Abstract: An overview of my involvement in pulsar research, which dates from early 1969 to the present, will be presented. This includes observations with many colleagues extending over the whole 55 years using the Parkes 64-m radio telescope (Murriyang), observations with the (now infamous) NRAO 300-ft transit radio telescope at Green Bank, West Virginia, from late 1969 to mid-1974 and, more recently, with the 500-m FAST radio telescope in Guizhou, China.

2024-12-16：

Session 10： Gravitatinal waves and dark matter-1 (Chairs：Dunc Lorimer)

10-1 Pulsar Timing Arrays and observation of the Hellings-Downs curve

Author: Bruce Allen
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Abstract: To show that they are observing gravitational waves, pulsar timing arrays "reconstruct" the correlation pattern between pulsars, and compare it to the 1983 prediction by Hellings and Downs (HD). The reconstruction is imperfect because (i) a finite set of pulsars at specific sky locations is used, (ii) the GW sources interfere, and (iii) the data are contaminated by noise. Here, I talk about recent work (arXiv:2407.10968) which predicts the amount by which the reconstruction is expected to differ from the HD curve. The variance is a ratio: the numerator depends upon the pulsar sky locations, and the denominator is the (effective) number of frequency bins for which the GW signal dominates the noise. In effect, after suitable combination, each such frequency bin gives an independent estimate of the HD correlation.

10-2 EPTA: observations and results

Author: Michael Kramer
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Abstract: In the summer of 2023, the European Pulsar Timing Array (EPTA) and Indian Pulsar Timing Array (InPTA) partnership jointly published evidence for the existence of an nHz-gravitational wave background. The unusually large cadence, frequency coverage and length of the data set not only yields the expected Hellings-Downs correlation curve, but also provides unique information on the spectrum of the GW background. This information is used to constrain new physics and dark matter models. The presentation will summarise the experiment, the results and give an outlook on the future.

10-3 The Future of NANOGrav and the DSA-2000

Author: Scott M. Ransom
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Abstract: In 2023, the pulsar timing array community announced strong evidence for the presence of a stochastic background of nanoHertz frequency gravitational waves. In North America, that evidence came from NANOGrav and included 15 yearsof data from the Arecibo and Green Bank Telescopes. While we can't yet say for certain what is causing the gravitational waves, our best guess is a population of slowly merging super-massive black hole binaries (SMBHBs) throughout the universe. No matter their source, the next decade should be incredibly interesting for this field, with a detailed characterization of the stochastic background, including it spectral shape and measurement of potential

anisotropies, and the likely detection of individual SMBHBs. Yet the loss of the Arecibo telescope has strongly impacted NANOGrav's gravitational wave sensitivity. That loss can be almost completely mitigated, and in some ways overcome (e.g. sky coverage) with the construction and operation of the DSA-2000. Using approximately 25% of its time, NANOGrav will continue play a leading role in nanoHertz gravitational wave science, as well as in a plethora of additional science that we get for ``free'' with high-precision pulsar timing, like tests of gravitational theories and robust masses of neutron stars.

10-4 The Indian Pulsar timing array

Author: Mayuresh Surnis
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Abstract:

10-5 Chinese Pulsar Timing Array Observation

Author: Heng Xu
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Abstract: The Chinese Pulsar Timing Array (CPTA) aims to detect nano-Hertz gravitational waves (GWs) using Chinese radio telescopes. With the first dataset from CPTA utilizing FAST spanning approximately 3 years, we have found evidence of a stochastic GW background. We continue to conduct pulsar timing observations at FAST, and additional data has been acquired, significantly expanding both the number of pulsars and the data length of our dataset. In this talk, we will present the latest CPTA dataset and updates in our data analysis.

10-6 Search for gravitational waves with the Chinese Pulsar Timing Array

Author: YanJun Guo
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Abstract: Observing and timing a group of millisecond pulsars with high rotational stability enables the direct detection of nano-Hz gravitational waves (GWs). The GW signals can be identified from the spatial correlations encoded in the times-of-arrival of widely spaced pulsar-pairs. The Chinese Pulsar Timing Array (CPTA) is a collaboration aiming at the direct GW detection with observations carried out using Chinese radio telescopes. In this talk I will present the GW search with CPTA dataset and discuss future prospects.

10-7 CPTA progress: Jitter analysis
Author: Bojun Wang
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Abstract: We presented measurements of jitter noise of 57 MSPs from CPTA program. We find that the levels of jitter can vary dramatically between different pulsars and our jitter values are generally lower compared to other PTAs' results. Due to the high sensitive of FAST, we are able to detect single pulses of 17 MSPs from our data sample and measured their frequency averaged pulse jitter through single pulse timing. We find significant frequency-dependence of jitter for PSR J0030+0451, PSR J0348+0432, PSR J0621+1002, PSR J1327+3423 and PSR J1713+0747. Finally, we discuss the comparison between jitter noise and Ecorr parameter. We report the intensity modulations and mode changing phenomena for several MSPs.

10-8 Single pulsar noise analysis and gravitational wave search with the CPTA
Author: SiYuan Chen
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Abstract: The Chinese Pulsar Timing Array (CPTA) PTAs has reported the finding of evidence for a gravitational wave (GW) signal in its first data release (DR1) in coordination with the European Pulsar Timing Array (EPTA) + Indian Pulsar Timing Array (InPTA), North American Nanohertz Observatory for Gravitational waves (NANOGrav) and Australian Parkes Pulsar Timing Array (PPTA), together as part of the International Pulsar Timing Array (IPTA) efforts towards detecting nanohertz gravitational waves.

While the overview paper has been published, a series of papers analyzing the data set in greater details is planned. I will present the analysis of the single pulsar noise models, which are needed to search for GW signals. We compare a DMX style data set against the DM power law GP model. Following other PTAs, we employ Bayesian techniques to optimize the frequency bin choice for the power law model. In addition, we use four software packages to verify our results. Finally, comparison against other PTA results show very broad agreement, however given the different frequency range that is probed by the 3 years long CPTA DR1, the comparison should be viewed with caution.

Session 11： Gravitatinal waves and dark matter-2 (Chairs：Bruce Allen)

11-1 The next big discovery of gravitational wave astronomy: gravitational waves from neutron stars
Author: Maria A. Papa
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Abstract: Nearly 200 mergers of compact binary objects have been observed since 2015, turning gravitational wave astronomy from the dream of a “niche” community, to a reality at the cutting edge of research. In 2017 the joint electromagnetic and gravitational-wave observation of a binary neutron star merger has opened the era of multi-messenger astronomy. More events like these are expected, at an ever increasing rate as the detectors’ sensitivity improves. But the gravitational wave sky is not just populated by transients. We expect there to be many sources constantly humming with nearly perfect pitch. So far these signals have eluded detection, but the hunt is on, and their discovery could well be the next big thing in gravitational wave astronomy. This is going to be the focus of my talk.

11-2 Continuous Gravitational Wave Searches with FAST Pulsars

Author: Brian Mc Gloughlin
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Abstract: Continuous gravitational waves are signals that are expected to be emitted by non-axisymmetric rotating neutron stars, such as pulsars. Detections of such signals could provide insights into the internal structure of astrophysical objects and the physics of extreme environments.

We demonstrate our approach for selecting continuous gravitational wave targets from the pulsars detected by FAST. In this context, we provide sensitivity estimates for the pulsar population identified by the FAST Galactic Plane Pulsar Snapshot Survey. Additionally, we highlight sample results for PSR J0520+3722 and other notable targets.

Finally, we highlight the crucial role of precise timing solutions and minimal uncertainty in pulsar parameters for enhancing the likelihood of detecting continuous gravitational waves.

11-3 Searching pulsars via gravitational waves channel

Author: Jing Ming
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Abstract: Pulsars are highly magnetized, rotating neutron stars that emit beams of electromagnetic radiation. Neutron stars with non-axisymmetric deformations or unstable r-modes are also expected to emit continuous gravitational waves. Detecting these continuous gravitational wave signals could allow us to discover pulsars whose beams of electromagnetic radiation do not point toward Earth.

The young central compact objects found in galactic super supernova remnants are particularly interesting because they are young and energetic. However, searching continuous waves from these spinning neutron stars is a highly challenging data

analysis problem. In order to extract these extremely weak signals from large data sets, a large amount of computational resources is required to cover the vast unknown waveform parameter spaces.

In this talk, I will introduce the efforts made by our Einstein@Home group to search for continuous gravitational waves from neutron stars in young galactic supernova remnants: Vela Jr. (G266.2-1.2), Cassiopeia A (G111.7-2.1), and G347.3 (G347.3-0.5).

11-4 The spatial correlations between pulsars for interfering gravitational-wave sources in pulsar timing array

Author: YanChen Bi
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Abstract: Pulsar timing arrays (PTAs), aimed at detecting gravitational waves (GWs) in the $1\sim 100$ nHz range, have recently made significant strides. The Hellings-Downs (HD) correlation, traditionally considered the criterion for detecting a gravitational-wave background (GWB), has been observed with compelling evidence in a common-spectrum signal. However, the HD curve is expected for discrete and non-interfering sources, which is unlikely to hold in realistic scenarios with interference among numerous GW sources, such as the supermassive black-hole binaries. In this article we reveal how such interference generates measurable frequency-dependent spatial correlations distinct from the HD curve. The spatial correlations for interfering sources (referred to as ``ISC'') still exhibit contributions in the quadrupole and higher orders, resembling the HD correlation and encoding the nature of GW radiations. We apply these novel correlations to search for a GWB in the NANOGrav 15-year data set. In an optimistic estimation, our findings show a Bayes factor of 33.7 ± 3.2 comparing ISC to the HD correlation, and an improvement in optimal statistic signal-to-noise ratio from 4.9 ± 1.1 for the HD correlation to 6.6 ± 1.7 for the ISC, highlighting the potential significant enhancement in evidence for detecting a GWB through incorporating interference.

11-5 The continuous gravitational wave treasure trove of dark neutron stars

Author: Benjamin Steltner
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Abstract: Of the estimated >~ 100 million galactic neutron stars, only ~3500 have been detected, mostly as pulsars with EM observations. A large fraction is hidden from EM observations since they are non-pulsating, their beam does not strike Earth or is occluded.

Some of these invisible neutron stars could be detected via another channel: tiny deformations/deviations from rotational symmetry in the neutron star continuously

emitting gravitational waves, omnidirectional and passing unobstructed through material.

Searches for these still elusive continuous gravitational waves can be computationally challenging, depending on how well we know the system parameters. We present an ongoing search to detect continuous gravitational waves from non-visible candidate neutron stars in eccentric binary systems identified in GAIA data.

This type of search serves as a blueprint for probing gravitational wave emission from neutron stars in binaries with parameters affected by large uncertainties, and we would like to use it on interesting pulsars candidates from FAST.

11-6 First Pulsar Polarization Array Limits on Ultralight Axion-like Dark Matter

Author: Jing Ren
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Abstract: Ultralight Axion-Like Dark Matter (ALDM) is characterized by its wave-like nature on astronomical scales and has a potential to address small-scale structure problems in local galaxies. As linearly polarized pulsar light travels through the ALDM galactic halo, its position angle can oscillate due to cosmic birefringence induced by the ALDM Chern-Simons coupling to electromagnetic field. Pulsar Polarization Array (PPA) is a powerful tool for detecting such an effect by cross-correlating the polarization signals across pulsars, and hence the ultralight ALDM. In this paper, we develop a framework to analyze the time-series data of PPA. We then conduct the first PPA analysis on ultralight ALDM, using the polarization data from 22 pulsars in the third data release of Parkes Pulsar Timing Array. For the mass range of $10^{-23} - 10^{-21}~{\rm eV}$, our results surpass existing ones, pushing the limits on the ALDM Chern-Simons coupling to approximately $10^{-14}-10^{-12}~{\rm GeV}^{-1}$. Furthermore, we demonstrate that the cross-correlation of PPA data is crucial for characterizing the nature of the derived limits.

11-7 Vetting quark-star models with gravitational waves in the hierarchical Bayesian framework

Author: ZiMing Wang
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Abstract: The recent discovery of gravitational waves (GWs) has opened a new avenue for investigating the equation of state (EOS) of dense matter in compact stars, which is an outstanding problem in astronomy and nuclear physics. In the future, next-generation (XG) GW detectors will be constructed, deemed to provide a large number of high-precision observations. We investigate the potential of constraining the EOS of quark stars (QSs) with high-precision measurements of mass m and

tidal deformability Λ from the XG GW observatories. We adopt the widely-used bag model for QSs, consisting of four microscopic parameters: the effective bag constant $B_{\rm eff}$, the perturbative quantum chromodynamics correction parameter a_4, the strange quark mass m_s, and the pairing energy gap Δ. With the help of hierarchical Bayesian inference, for the first time we are able to infer the EOS of QSs combining multiple GW observations. Using the top 25 GW events in our simulation, we find that, compared with the loudest event only, the constraints on $B_{\rm eff}$ and Δ are tightened by several times, while a_4 and m_s are still poorly constrained. We also study a simplified 2-dimensional (2-d) EOS model which was recently proposed in literature. The 2-d model is found to exhibit significant parameter-estimation biases as more GW events are analyzed, while the predicted m-Λ relation remains consistent with the full model.

11-8 Detection of Gravitational Wave Memory Using Pulsar Timing Arrays

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Abstract: Gravitational waves are a crucial prediction of general relativity, representing a manifestation of spacetime curvature. This report focuses on nanohertz gravitational wave signals, which are a lower frequency type of gravitational wave. Currently, pulsar timing arrays (PTA) are the only feasible detection method. During the merger of supermassive binary black holes, spacetime undergoes rapid and permanent step-like changes, accompanied by the propagation of gravitational waves, resulting in the gravitational wave memory effect. This memory effect is a time-domain phenomenon that has a long-term impact on the frequency of pulsars and can be accumulated through long-term observation.

This report will introduce the principles and methods of using pulsar timing arrays to detect the gravitational wave memory effect, followed by the presentation of some research results based on the PPTA DR3 dataset.

Session 12：Internal Structure (Chairs：Li Zhang)

12-1 Pulsars: Neutron/Strangeon Stars?

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Abstract: Pulsars are useful in both science and engineering, but their nature is still a puzzle even after more than half a century of the discovery. The first answer was presented by Lev Landau who, in the late age of developing quantum mechanics, superficially anticipated a neutron-rich star that has been developed into the concept of neutron star in the mainstream now. However, strangeness should play an essential role in determining the nature of pulsar, especially after the establishment of the

standard model of particle physics in 1960s. We argue that pulsars could be strangeon stars, which would be welcome for new observations, from massive pulsars and low tidal effect to gamma-ray bursts and fast radio bursts.

12-2 Observational effects of strange quark stars

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Abstract: The internal structure of pulsars is still largely uncertain. It has been suggested that strange-quark matter (SQM) may be the true ground state of hadronic matter, indicating that the observed pulsars may actually be strange stars (SSs), but not neutron stars. According to the SQM hypothesis, the existence of a hydrostatically stable sequence of SQM stars has been predicted, ranging from 1 to 2 solar mass SSs, to smaller strange dwarfs and even strange planets. While gravitational wave (GW) astronomy is expected to open a new window to the universe, it will shed new light on the search for SQM stars. We show that due to their extreme compactness, strange planets can spiral very close to their host SSs without being tidally disrupted. We thus can try to identify strange quark objects by searching for close-in pulsar planets. Additionally, Like inspiraling neutron stars or black holes, a merging strange star-strange planet system would serve as new sources of GW bursts, producing strong GWs at the final stage. The events occurring in our local universe can be detected by GW detectors, such as Advanced LIGO and the future Einstein Telescope. This effect provides a unique probe to SQM objects and is hopefully a powerful tool for testing the SQM hypothesis.

12-3 Evolution of pulsars and its interior equation of state

Author: Xia Zhou
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Abstract: In this talk, I will introduce our recent work on pulsar spin and thermal evolution, particularly focusing on the properties related to pulsar rotation and its internal structure, eos and dynamical processes.

12-4 Magnetar Precession and Superfluid Dynamics

Author: Erbil Gügercinoğlu
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Abstract: The recent radio polarization variation observation of the magnetar XTE J1810-197 following an X-ray outburst indicates that magnetars undergo precession. In this talk, I will elaborate on implications of the precession for the superfluid

dynamics of magnetar interior by applying the vortex creep model, and derive the physical quantities like superfluid coupling time and vortex line-flux tube interaction strength from the observed parameters. I will also discuss possible directions for the repeating Fast Radio Bursts (FRBs).

12-5 Radial oscillations of proto-neutron stars

Author: TingTing Sun
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Abstract: We investigate radial oscillations of proto-neutron stars, employing equations of state described by the Brueckner-Hartree-Fock theory or the relativistic mean field model, and assuming isentropy and fixed lepton fractions for the internal structure. We calculate the eigenfrequencies and corresponding oscillation functions, which show different characteristics in different mass regions. In the low-mass region around $1.4\ms$, the radial oscillation frequencies are lowered by large entropy and neutrino trapping, along with a reduction of the average adiabatic index. In the region close to the maximum mass, the fundamental oscillation frequency drops rapidly and vanishes at the maximum mass, in accordance with the critical stability criterion $\partial M /\partial \rho_c = 0$, as for cold neutron stars.

12-6 Neutron Stars in Bumblebee Theory of Gravity

Author: PeiXiang Ji
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Abstract: In recent times, theoretical research on the bumblebee model has flourished, with a simultaneous increase in the utilization of observations to impose constraints on it. We systematically researched the structure of neutron stars and the corresponding spacetime within this theory, hoping it will improve our understanding of the theory and the role of vector fields in the Universe.

12-7 Moment of inertia for axisymmetric neutron stars in the standard model extension

Author: YiMing Dong
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Abstract: We develop a consistent approach to calculate the moment of inertia (MOI) for axisymmetric neutron stars (NSs) in the Lorentz-violating Standard-Model Extension (SME) framework. To our knowledge, this is the first relativistic MOI calculation for axisymmetric NSs in a Lorentz-violating gravity theory other than deformed, rotating NSs in general relativity. Under Lorentz violation, there is a

specific direction in the spacetime, and NSs get stretched or compressed along that direction. When a NS is spinning stationarily along this direction, a conserved angular momentum and the concept of MOI are well defined. In the SME framework, we calculate the partial differential equation governing the rotation and solve it numerically with the finite element method to get the MOI for axisymmetric NSs caused by Lorentz violation. Besides, we study an approximate case where the correction to the MOI is regarded solely from the deformation of the NS and compare it with its counterpart in the Newtonian gravity. Our formalism and the numerical method can be extended to other theories of gravity for static axisymmetric NSs.

Session 13：Propagation effects (Chairs：Dick Manchester)

13-1 Pulsar interstellar scintillation study using FAST
Author: JuMei Yao
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Abstract:

13-2 FRB scintillation studies with FAST
Author: ZiWei Wu
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Abstract: In this presentation, I will briefly introduce the difficulties of understanding fast radio bursts (FRBs) origin and the potential applications of interstellar scintillation (ISS) on this topic. In particular, I will introduce the ISS progress of FAST FRB key science projects.

13-3 FAST-Effelsberg simultaneous observation of pulsar scintillation screen
Author: Xun Shi
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Abstract: Simultaneous intensity observations by multiple telescopes can provide wide-band phase information of pulsar scintillation screens. I will present FAST-Effelsberg simultaneous observations of PSR B1508+55.

13-4 Calculating DM with single pulse using minimum entropy
Author: YuFu Shen
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Abstract: The minimum entropy method has advantages at low SNR, making it applicable to single-pulse DM analysis while also considering the contributions of sub-pulses.

13-5 Pulsar scattering observed by FAST

Author: WeiCong Jing
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Abstract: The turbulence in ionized interstellar medium (IISM) cause radio wave diffracted, scattered and propagating in multiple paths. A resultant phenomena is IISM scattering on the signal from radio pulsars, an asymmetric broadening on radio pulse. FAST-GPPS is a pulsar survey on the Galactic plane by the FAST L-band receiver. In this talk, we introduce the results of FAST-observed scattered pulsars and show the Arm-dependent turbulence strength.

13-6 Pulsar rotation measures and the Galactic magnetic fields revealed by FAST

Author: Jun Xu
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Abstract: The Galactic Plane Pulsar Snapshot (GPPS) survey with the Five-hundred-meter Aperture Spherical radio Telescope (FAST) has discovered 718 new pulsars and redetected many known pulsars. We determined more than two hundred rotation measures by processing the polarimetric data for these newly-discovered pulsars and also previously known pulsars. Through analysis of all available RMs of pulsars, we study the magnetic fields in spiral arms in the first quadrant disk.

Session 14： Pulsars in Globular Clusters (Chairs：Na Wang)

14-1 Exotic Pulsars in Globular Clusters

Author: Scott M. Ransom
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Abstract: In the past five years, the number of known globular cluster pulsars, most of them of the millisecond variety, has basically doubled, to more than 330. The main reasons were the commissioning of the extremely sensitive FAST and MeerKAT radio telescopes, and increased computing power applied to the searches themselves. In this talk I'll mention some of the fascinating exotic systems that have been found,

discuss the importance of long-term timing of these systems, and hint at the astrophysics and basic physics those systems will provide.

14-2 Globular Clusters GMRT Pulsar Search (GCGPS): Discoveries and further studies

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Abstract: Globular Clusters (GCs) are the gravitationally bound star clusters in the galaxy. Due to their compactness and high collision rate, the clusters become the formation hub of millisecond pulsars (MSPs). The pulsars' properties in the globular clusters are quite different from those of the other Galactic pulsars due to their different evolutionary paths, making them most interesting for studying the underlying population.

Benefitted from the sensitivity enhancement with the upgraded Giant Metrewave Radio Telescope (uGMRT) and steep spectral nature of the pulsars, we designed a survey called Globular Clusters GMRT Pulsar Search (GCGPS) to search for MSPs in the GCs in the low-frequency range using uGMRT (300-750 MHz using Band-4 and Band-3 of uGMRT), where the pulsar search remained mostly unexplored by the previously conducted surveys. We started the survey GCGPS in 2023 and it is presently operational. Within one and a half years of operation timescale, we discovered seven new MSPs in four different GCs. All of the four GCs associated with the GCGPS discovered MSPs had previously had no discovered MSPs in them, making the GC dispersion measures (DMs) known very precisely from these discoveries.

Timing of the MSPs revealed that one MSP is in a highly relativistic compact orbit with an orbital period of ~ 19 hours and eccentricity of ~ 0.54. Having this highly eccentric compact orbit, we were able to measure one post-keplarian (PK) parameter for this system allowing direct measurement of the total mass of the system. Also for the other six MSPs, there are two isolated MSPs, one binary MSP in a wide orbit (orbital period of ~ 30 days) system, one in a moderately compact orbit (orbital period of ~ 1.98 days) and the other two systems are yet to analyze.

14-3 FAST Globular Cluster Pulsar Survey

Author: ZhiChen Pan
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Abstract: Since initiated in 2017, FAST Globular Cluster Pulsar Surver (GC FANS) got 56 pulsars and 3 very good candidates till the end of November 2024. Started with the first surprising eclipsing redback M92A discovered in October 2017, these discoveries are mostly millisecond pulsars and more than half are binaries, including

6 spiders and 1 double neutron star system. I will talk about some our record breaking studies including the 53-min. binary M71E, the 467-day binary M71B, the 4-s spinning pulsar M15L, and the on-going studies with more exciting and promising results in either pulsar search methods or pulsar sciences.

14-4 New pulsars in globular clusters NGC 6517, M92 and M13 by FAST

Author: DeJiang Yin
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Abstract: I will present the results of pulsar search in globular cluster NGC 6517 using FAST, and the simulation analysis of pulsar population in globular cluster of the Milky Way.

In addition, the new pulsars recently discovered by reprocessing the globular clusters M92 and M13 archival data of FAST will also be briefly presented.

14-5 Pulsars in M3 and the new pulsars in M2 and Glimpse-C01

Author: Baoda Li
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Abstract: I will present the timing solutions of the newly discovered pulsars M3E and F in M3, and the preliminary study of pulsar scintillation in M3 is also reported. On the other hand, I report the newly discovered pulsars in M2 and Glimpse-C01.

14-6 Discovery of a Millisecond Pulsar Associated with Terzan 6

Author: ShiJie Gao
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Abstract: Observations show that globular clusters (GCs) might be among the best places to find millisecond pulsars (MSPs). However, the GC Terzan 6 seems to be an exception without any pulsar discovered, although its high stellar encounter rate suggests that it harbors dozens of them. We report the discovery of the first radio pulsar, PSR J1750–3116A, likely associated with Terzan 6 in a search of C-band (4–8 GHz) data from the Robert C. Byrd Green Bank Telescope with a spin period of 5.33 ms and dispersion measure (DM) ≃ 383 pc cm-3. The mean flux density of this pulsar is approximately 3 μJy. The DM agrees well with predictions from the Galactic free electron density model, assuming a distance of 6.7 kpc for Terzan 6. PSR J1750–3116A is likely an isolated MSP, potentially formed through dynamical interactions, considering the core-collapsed classification and the exceptionally high stellar encounter rate of Terzan 6. This is the highest radio frequency observation that has

led to the discovery of a pulsar in a GC to date. While L-band (1–2 GHz) observations of this cluster are unlikely to yield significant returns due to propagation effects, we predict that further pulsar discoveries in Terzan 6 will be made by existing radio telescopes at higher frequencies.

14-7 Search for pulsars in globular clusters based on stacking power spectra
Author: Yinfeng Dai
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Abstract: This report presents a pulsar search method which is based on stacking power spectra. New pulsars have been detected in globular clusters. The discovery of these new pulsars is thanks to the analysis of stacked power spectra of the archival observation of FAST.

14-8 Searching for pulsars in globular clusters using Fast Folding Algorithm
Author: YaoWei Li
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Abstract: The globular clusters, famous as pulsar factories, contain a large number of pulsars. Most of them are millisecond pulsars， but there are few long-period pulsars. The sensitivity of the fast folding algorithm (FFA) is higher than the Fast Fourier Transform (FFT)， especially for long-period pulsars. We used the FFA to search for partial observations of globular clusters within the FAST sky.

14-9 Progress of the QTT project
Author: Na Wang
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Abstract:

14-10 Constraints on neutron star interiors from pulsar timing
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Abstract:

2024-12-17：

Session 15： Emission mechanism-2 (Chairs：RenXin Xu)

15-1 Electrodynamics and Radiative Emissions of Magnetars

Author: Chris. Thompson
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Abstract: Magnetars are detectable as hyperluminous transient sources both inside and outside our Galaxy, allowing detailed study of their electrodynamic properties leading up to outburst. Understanding magnetar behavior depends on connecting their plasma state with the quantum interactions of photons, electrons and positrons. These interactions are qualitatively altered by the super-Schwinger magnetic field. Small-scale current structure appears to play a fundamental role in magnetar radio and X-ray emission, both in quiescent pulsating states and during bright bursts. There are also interesting connections between the solid response of the magnetar crust to the evolving magnetic field and the magnetospheric fireworks.

15-2 Accelerating potential and secondary plasma density profile in orthogonal pulsars magnetosphere

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Abstract: A new method to determine accelerating potential above radio pulsar polar caps is presented. The main advantage of considered method is that it is applicable for pulsars with an arbitrary inclination angle of the magnetic axis to rotation one, including orthogonal rotators which have non-axisymmetric secondary plasma density profiles. The approach is based on the well-known vacuum gap model where a gap height is assumed to be dependent on the position on the polar cap. Thus a vacuum region geometry becomes non-trivial and should be determined self-consistently with a solution for a corresponding Poisson equation. To do so, an iterative procedure was constructed. Knowing accelerating potential profile we were able to determine transverse profiles and absolute density of a secondary pulsar plasma, which in turn allowed us to calculate mean profiles of orthogonal interimpulse pulsars.

15-3 Radio emission in entire pulsar rotation phases

Author: PengFei Wang
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Abstract: A model on polarized radio emission from the entire pulsar magnetosphere is proposed. With the model, distribution of emission intensity is mapped over the whole rotation phases, all the sight line directions and various heights. The model predicts that polarized radio emission extends to the whole rotation phases, but which is most likely produced by pulsars with small periods and with the magnetosphere

filled with much more relativistic particles. The whole phase emission can be detected from either one pole or two poles of the magnetospheres. Despite the pulsed emission, impulsive emission can also be generated from the magnetosphere. The circular polarization is about zero for quasi symmetric distributions of relativistic particles within a static magnetosphere. Sensitive observations of PSRs J0953+0755 and J1932+1059 by FAST exhibit broad dynamical ranges for the emission, which ranges from the peak to less than 1/10000 the peak intensity. With the model, poleward or equatorward cutting of one or both poles of the beams can be distinguished.

15-4 Decoding the Nature of Coherent Radio Emission in Pulsars

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Abstract: The essential way to understand the characteristics of the process is to examine the polarization properties of individual pulses. Time samples with high levels of linear polarization reproduce the S-shaped curves that closely resemble the rotating vector model for the ordinary and extraordinary modes, the two eigenmodes of the relativistic electron-positron plasma. The polarizations of these modes are perpendicular to one another. Moreover, certain observations suggest that the orientation of the observed polarization vector should either align with the plane of the curved dipole field or be orthogonal to it. These observations severely limit the successful mechanism's sensitivity to the direction of the bent magnetic field plane. This characteristic is inherent to the coherent curvature radiation mechanism. We also discuss two crucial conditions that any model of pulsar radio emission must meet: the radio wave escape from the pulsar's magnetosphere and the degree of circular polarization. The data are consistent with the traditional model of the pulsar magnetosphere, which states that the radio emission should separate from the plasma at heights of less than 10% of the light cylinder radius. We show that the sparking process creates a moving plasma flow in the partially screened gap model of the inner acceleration area. Without making any more assumptions, the nonstationary plasma flow naturally satisfies the observed features of the radio emission.

15-5 On the Origin of Thunderstorms and Raindrops in PSR B2111+46

Author: BiPing Gong
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Abstract: PSR B2111+46 exhibits thunderstorms and raindrops states, which has not been well understood in the context polar cap based radiation model. Here I show that a differential rotation triggered fast magnetic reconnection near light cylinder can well accout for the behaviors of this pulsar. Moreover, the scenario provides a new

insight into the similarities and discrepencies among old pulsars, normal pulsars, and young pulsars.

15-6 Radio fan beam produced in the pulsar magnetosphere

Author: HongGuang Wang
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Abstract: The fan beam model is a kind of radio emission beam model proposed in 1980s. Assuming that the radio emission of relativistic charged particles in pulsar magnetosphere is broadband, the particles can produce a radially extended fan beam. In this talk I will present the observational tests for this kind of model and its application to studies on pulsar population and magnetosphere structure.

15-7 Extreme Physics of Radio Pulsars

Author: Ashley Bransgrove
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Abstract: Radio pulsars display a range of puzzling behavior in their magnetospheric emission and spin-down. In this talk I will describe exciting recent progress in modelling pulsar radio emission from first principles. I will also discuss a radio anomaly observed in the Vela pulsar, and how it could be used to probe the existence of quantum fluids in neutron star interiors. Finally, I will discuss the internal magnetic field evolution of pulsars, and how it relates to various observables, including star quakes, changes in the radio pulse profile, and the pulsar braking index.

Session 16： Magnetar, population and evolution (Chairs： Jarek Dyks)

16-1 Birth conditions of magnetars and central compact objects revealed from supernova remnants

Author: Ping Zhou
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Abstract: Marking the spectacular deaths of stars and white dwarfs, supernovae (SNe) are among the most energetic explosions in galaxies. Core-collapse SNe leave supernova remnants (SNRs) and also create compact remnants such as neutron stars, which share the progenitor stars and SN explosions with the SNRs. Magnetars and central compact objects make two extreme groups of neutron stars with ultra-strong and weak dipole magnetic fields compared to normal pulsars. I will talk about how we can learn the birth origin of magnetars and central compact objects through multi-wavelength observations of their host SNRs.

16-2 Radio Observations of Pulsar Wind Nebula

Author: Stephen C.-Y Ng
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Abstract: The rotational energy of a pulsar is mainly carried away by magnetized particle outflow called a pulsar wind. The confinement of the wind by the ambient medium results in a termination shock and the shocked particles inflate a bubble that emit broadband synchrotron and inverse-Compton emission known as a pulsar wind nebula (PWN). Due to long synchrotron cooling time, radio observations can trace integrated history of a PWN, complementing information obtained from the higher energy bands. In addition, radio polarization measurements can offer a powerful probe of the PWN magnetic field structure. Altogether these can reveal the physical conditions and evolutionary history of a system. In this talk, I will report on recent radio observational results of PWNe and discuss the multiwavelength connections.

16-3 Pulsar Wind Nebula, TeV Halo and Hadronic PeVatron

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Abstract: Two kinds of objects associated with pulsar dominate the very-high-energy and ultra-high-energy gamma-ray population. On one hand, pulsar wind nebule (PWNe) are one of promising candidates accelerate particle at least to PeV energy, named PeVatron. Traditionally, PWNe are thought to be leptonic-dominated which suffer Klein-Nishina effect near PeV. Thus, a hadronic origin is considered to explained PeVatron found by LHAASO. On the other hand, TeV halos around pulsars with small coefficient become one kinds of large extension gamma-ray sources. I will talk about our progress on these two topics.

16-4 Radio Study of the Pulsar Wind Nebula G11.2-0.3

Author: YiHan Liu
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Abstract: Pulsar wind nebulae (PWNe) are important sources for understanding galactic high-energy processes, but it is controversial until now about how high-energy particles in PWNe are accelerated and transported. Searching for counterparts of X-ray PWN (the proposed acceleration sites) in radio bands gives essential information (e.g., multi-band synchrotron spectrum and magnetic field) for related theories and future simulations, but has been rarely successful in radio observations.

Our recent 3 and 6 cm high-resolution observations of G11.2-0.3 PWN with the Australia Telescope Compact Array (ATCA) show morphological similarity with its X-ray PWN (a torus/jet feature), which is quite unique. Spectral indices of the radio

torus and jet are around -0.2 and 0.0, respectively. Meanwhile for the jet region, the spectral break between radio and X-ray spectra implies particle acceleration mechanisms like magnetic reconnection near the pulsar. Polarization results suggest a helical B-field inside the jet, the equipartition B-field strength of which is around 58 uG.

16-5 Anisotropic leptonic model for high energy emission around pulsars and pulsar wind nebulae

Author: YiFan Sun
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Abstract: High energy gamma-ray emission has been observed around pulsars and pulsar wind nebulae, creating objects like TeV halos (extended gamma-ray halos) and gamma-ray filaments. They can be explained by the inverse Compton scattering between leptons from the pulsar outflow and the cosmic microwave background photons. This population of high energy particles is also expected to emit synchrotron radiation up to the X-ray energy range. However, people have observed different morphology in radio to X-ray band for many of these objects. In this work, we propose a new model to consider small pitch angles between the particles and the magnetic field lines, so that synchrotron emission and IC emission can have different morphology. We perform detailed modeling of the evolution of particles' pitch angle and their emission profiles. We also compare our predictions with observations of candidate sources.

16-6 GTC optical/NIR upper limits and NICER X-ray analysis of SGR J1935+2154 for the outburst in 2022

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Abstract: The Galactic magnetar SGR J1935+2154 has undergone another prolific outburst since 2022 October 10. We present the results of searching for an optical/NIR counterpart of SGR J1935+2154 before and during this outburst. No counterpart was detected at the magnetar's position in r′ and z′ bands, providing stringent upper limits of r′ ≳ 28.65 and z′ ≳ 26.27. We also analyzed archival X-ray data from NICER to study the evolution of X-ray properties during the outburst. The spectra of the persistent emission and bursts can be well fitted by an absorbed power-law plus a blackbody model and an absorbed blackbody model, respectively. The burst flux F showed a power-law distribution of $N \propto F^{-0.71\pm0.10}$ for flux $\gtrsim 1.8 \times 10^{-9}$ erg cm^{-2} s^{-1}, while the temperature and radius followed a lognormal distribution with $kT = 1.63^{+0.73}_{-0.50}$ keV and $R_{bb} = 4.35^{+1.95}_{-1.35}$ km, respectively. Using the near-infrared (NIR) and X-ray emission, together with the optical/NIR upper limits, we discussed the origin of the NIR emission from the

magnetar based on the fallback disk model and magnetosphere model. We found that either models cannot be ruled out with currently available data. Further MIR observations are needed to find out the mechanism for producing the NIR emission from SGR J1935+2154.

16-7 Burst Properties of the New Magnetar Swift J1555.2-5402

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Abstract: Swift J1555.2-5402, a newly discovered magnetar, was first detected on June 3, 2021, through a Swift/BAT trigger. In this study, we investigate the observational characteristics of Swift J1555-5402, focusing on its short bursts detected by various high-energy telescopes, including Swift/BAT, Fermi/GBM, GECAM, and NICER. Using Bayesian block analysis, we identify and analyze 27 short bursts observed by GBM, with each burst well-fitted by a single blackbody spectrum. Additionally, we extend our analysis to GECAM observations, identifying 15 bursts, and perform joint spectral fits for those observed in conjunction with GBM. Our investigation reveals interesting trends in burst rates during the outburst decay phase, indicating variations in detection sensitivity among different instruments. Notably, NICER observes a lower burst rate during the outburst decay compared to the first month post-trigger, while Swift/BAT, Fermi/GBM, and GECAM maintain relatively stable detection rates. We also explore the burst duration distribution and its best Gaussian fit for both GBM and GECAM bursts, providing insights into the temporal properties of Swift J1555-5402's magnetar activity. The spectral analysis of bursts, including their fluence, temperature, and other parameters, provides valuable insights into the underlying physical processes. Our results contribute to a comprehensive understanding of the magnetar's short burst behavior and demonstrate the effectiveness of multi-instrument observations in unraveling the intricacies of high-energy astrophysical phenomena.

16-8 The Pulsar Tree: Visualizing the Pulsar Population Using Graph Theory Techniques.

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Abstract: This talk will present an innovative application of graph theory using a type of graph known as the Minimum Spanning Tree (MST). This technique provides a novel tool to visualize and classify the population of pulsars by representing them together with their properties as nodes and edges through the MST, offering relationships and groupings that go beyond the traditional P-Pdot diagram. The application of this method to the entire population of pulsars cataloged in the ATNF

reveals behaviors and connections that are not easy to discern with traditional methods.

The MST approach to the population of millisecond pulsars (MSPs) will be demonstrated, highlighting features and identifying possible key candidates for black widows, redbacks, and transitional millisecond pulsars (tMSPs). This could provide new insights into their behaviors and classifications.

In addition, it will be shown how the MST can act as an unsupervised method of classification for fast radio bursts (FRBs) distinguishing between repeaters and non-repeaters. The analysis reveals clusters with a high density of repeaters, suggesting possible repeater candidates and offering a new perspective on the classification of FRBs.

This innovative visualization tool helps to identify targets for future observations.

16-9 On the evolution of magnetic inclination angles in the radio pulsars with emission outside the radio range

Author: Mariia Timirkeeva
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Abstract: The constructed distributions of angles β for the objects radiating in different ranges can establish clear differences in the groups being investigated. We selected three groups of isolated neutron stars for subsequent analysis: in the first group there are only radio-loud pulsars those are thought to be quiet in the X-ray and gamma-ray ranges (R group); in the second group there are radio pulsars with detected gamma-ray emission—radio-loud gamma-ray pulsars (γ+ R pulsars); and the third group consists of radio pulsars with detected X-ray emission - radio-loud X-ray pulsars (X + R pulsars). For this purpose, we have calculated the values of angles β separately for objects from each group by two different methods.

It has turned out that in pulsars with hard emission the mean values of this angle (28.2◦ and 28.8◦) are higher than those for quiet radio pulsars (12.9◦). However, using the Kolmogorov–Smirnov test, we have shown that the revealed difference is insignificant with a high probability. Consequently, the structures of the magnetospheres in the three groups of pulsars considered do not differ significantly, while their difference is caused by high values of magnetic field on the light cylinder. This leads to the switching on

the non-thermal emission mechanism in pulsars with detected X-ray and/or gamma-ray emission but is not enough for this in radio pulsars without the hard emission. Some knowledges based on other methods are required , which can give us information on the orientation of the axes in the pulsars and serve as a further development of the theoretical view on the structure of pulsar magnetospheres.

16-10 Pulsar Population Synthesis with Magneto-Rotational Evolution: Constraining the Decay of Magnetic Field

Author: ZhiHong Shi
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Abstract: We present a population synthesis model for normal radio pulsars in the Galaxy, incorporating the latest developments in the field and the magneto-rotational evolution processes. Our model considers spin-down with force-free magnetosphere and the decay of the magnetic field strength and its inclination angle. The simulated pulsar population is fit to a large observation sample that covers the majority of radio surveys using Markov Chain Monte Carlo (MCMC) technique. We compare the distributions of four major observables: spin period (P), spin-down rate, ($\dot{P}$), dispersion measure (DM) and radio flux density, using accurate high-dimensional Kolmogorov-Smirnov (KS) statistic. We test two B?field decay scenarios, an exponential model motivated by Ohmic dissipation and a power-law model motivated by the Hall effect. The former clearly provides a better fit and it can successfully reproduce the observed pulsar distributions with a decay time scale of ~8.3 (+3.9 -3.0) Myr. The result suggests a significant B-field decay in aged pulsars and Ohmic dissipation could be the dominant process.