Fast Radio Bursts 2023

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Book of Abstracts

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A LOFAR sample of luminous compact radio sources coincident with nearby dwarf galaxies

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The vast majority of extragalactic, compact continuum radio sources are associated with star formation or jets from (super)massive black holes and, as such, are more likely to be found in association with starburst galaxies or early type galaxies. Recently, two new populations of radio sources have been identified: (a) compact and persistent sources (PRS) associated with fast radio bursts (FRBs) in dwarf galaxies and (b) compact sources in dwarf galaxies that could belong to the long-sought population of intermediate-mass black holes. Despite the interesting aspects of these newly found sources, the current sample size is small (a few to dozens), limiting scrutiny of the underlying population. Here, we present a search for compact radio sources coincident with dwarf galaxies. We search the LOFAR Two-meter Sky Survey (LoTSS) – the most sensitive large-area survey for optically thin synchrotron emission to date. Exploiting LoTSS' high spatial resolution (6 arcsec) and high astrometric precision (about 0.2 arcsec), we match its compact sources to the compiled sample of dwarf galaxies in the Census of the Local Universe. We identify 29 over-luminous compact radio sources, evaluate probability of chance alignment, investigate the potential nature of these sources, and evaluate their volumetric density and rate. While optical line-ratio diagnostics on the nebular lines from the host galaxies prefer a star-formation origin over an AGN origin, future high angular resolution radio data is necessary to ascertain the origin of the radio sources. We discuss planned strategies to differentiate them between candidate FRB hosts and intermediate-mass black holes.

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Revisiting the Mysterious Origin of FRB 20121102A with Machine-learning Classification

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Fast radio bursts (FRBs) are strong and rapid radio waves from the universe. Even though more than 50 physical models have been proposed, the origin and physical mechanism of FRB emissions are still unknown. The classification of FRBs is one of the primary approaches to understanding

their mechanisms, but previous studies have been limited by small and heterogeneous samples. The FRB classification has been conducted conventionally using only a few observational parameters, such as fluence and duration, which might miss some new FRB classes. To overcome this problem, we use homogeneous 977 FRB samples of FRB 20121102A detected by the Arecibo telescope in this work. We adopt an unsupervised machine-learning model, the Uniform Manifold Approximation and Projection (UMAP) to classify, allowing us to handle 8 parameters simultaneously, including amplitude, linear temporal drift, time duration, center frequency, bandwidth, scale energy, fluence, and dispersion measure.

Our machine-learning analysis identified four distinct clusters, indicating the possible existence of four different physical mechanisms responsible for the observed FRBs from the FRB 20121102A source. This research will be a benchmark for future FRB classifications when dedicated radio telescopes such as the Square Kilometer Array (SKA) or BURSTT discover more samples than before.

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FRBs as probe to understand cosmological phenomena

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Fast Radio Bursts (FRBs) can be used as a tool to understand different cosmological phenomena because of their distinct features, such as short pulse width, relatively high dispersion measure, etc. In my talk, I will particularly focus on two distinct events, viz. ultra-high-frequency gravitational waves (GWs) and primordial mass black holes. It was already shown that the Gertsenshtein-Zel'dovich (GZ) effect can be one of the mechanisms for the formation of FRBs. I will explain that if the current or any proposed GW detectors detect any continuous GW signal from the site of FRBs, this might disprove the merger-like theories and provide significant support for the GZ theory; thereby confirming the high-frequency GWs. Moreover, using lensing in FRBs, I will show that modified gravity adds a screening effect on gravitational lensing similar to the case when there is plasma in the path of the light ray acting as a scattering screen.

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An all-sky Fast Radio Burst monitor with phased array

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Large field of view (FoV) facilities have been playing irreplaceable roles in the blind search for fast radio bursts (FRBs), which are mysterious radio flash occurring in the full sky. In this talk, I will start by introducing the known large FoV facilities and forthcoming all-sky instruments for FRB surveys. Given the basic system parameters of the Parkes cryogenically-cooled phased array feed, then I will present the idea to build an all-sky FRB monitor using phased array receiver. To test the FRB detectability, we perform Monte Carlo simulations on several large FoV instruments based on the FRB luminosity function. I will be talking about the detection rate and parameter space we can

explore using the all-sky FRB monitor. Finally, I will summarise the simulation results and provide some prospects on the instrumentation.

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We teamed up Apertif + LOFAR on the FRB sky. Here's what we learned about the emission mechanism.

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Identifying the physical nature of Fast Radio Burst (FRB) emitters requires good localisation of more detections, and broadband studies enabled by real-time telescope combinations. I will present the results from the Apertif FRB survey (ALERT) that ran 2019-2022, focusing on what we learned about the FRB emission – a mechanism that must be uniquely energetic. ALERT performed wide-field, fully coherent, real-time FRB detection and localisation on the Westerbork interferometer. We detected a new FRB every week of observing, interferometrically localised to ~0.4-10 sq.arcmin, leading to confident host associations.

The 24 discovered FRBs are broad band and very narrow, of order 1ms duration. Only through our very high time and frequency resolution are these hard-to-find FRBs detected, producing an unbiased view of the intrinsic population properties. Combining these results with powerful population synthesis using FRBPOPPY allows us to determine the spectral index and the fluence distributions, constraining the emission mechanism. The fraction of Apertif bursts with multiple components is much larger than seen by CHIME/FRB: this morphological evolution with frequency is an important clue for, e.g., a magnetospheric origin. Temporal, 'micro-structure'-like behavior corroborates the hypothesis for the nature of the emission.

The Apertif combination of detection rate and localisation accuracy exemplified by the ALERT FRBs marks a new phase in which a growing number of bursts can be used to probe our Universe.

Finally, we cojoined Apertif and LOFAR through real-time alerting. Using simultaneous radio data spanning over a factor 10 in wavelength, we detected FRB emission below 300 MHz for the first time. We thus show that FRBs can emit at low frequencies, and that some FRBs live in clean environments – a prerequisite for certain FRB applications to cosmology.

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Expanding Fireball in Magnetar Bursts and Fast Radio Bursts

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FRB 20200428A is an exceptional fast radio burst (FRB) from a Galactic magnetar, SGR1935+2154, and is associated with hard X-ray short bursts. Expanding fireball model is one of the models that explain the hard X-ray short bust and FRB from the magnetar. A fireball of radiation plasma created near the surface of a neutron star (NS) expands under its own pressure along magnetic field lines, and produces photon emission and relativistic matter outflow. We comprehensively classify the expanding fireball evolution into five cases and obtain the photospheric luminosity and the kinetic energy of the outflow, taking into account key processes; lateral diffusion of photons escaping from a magnetic flux tube, effects of strong magnetic field, baryon loading from the NS surface, and radiative acceleration via cyclotron resonant scattering, some of which have not been considered in the context of gamma-ray bursts. Applying our model to magnetar bursts with FRBs, in particular the X-ray short bursts from SGR 1935+2154 associated with the Galactic FRB 20200428A, we show that the radiation can accelerate the outflow to high Lorentz factor with sufficient energy to power FRBs.

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Investigating the FRB-magnetar connection in a sample of nearby galaxies

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Fast radio bursts (FRBs) are intense, millisecond-long radio signals of unknown extragalactic origin. The detection of the very first galactic FRB-like signal from the magnetar SGR J1935+2154 has strengthened the connection between FRBs and magnetars. Using the Northern Cross radio telescope, we conducted a targeted search for FRBs in a sample of seven nearby galaxies, with a total observation time of ~ 700 hours. Our observational campaign yielded one FRB detection in the direction of the galaxy M101, observed with a $\mathrm{DM} = 303$ pc cm^{-3}, which supports the idea that it originated from a much distant source. Considering that no significant detection comes indisputably from the selected galaxies we place an upper limit of 0.4 yr^{-1} on the rate of FRBs from magnetars like SGR J1935+2154. This result disfavors magnetars like SGR J1935+2154 as the sole progenitors of cosmological FRBs, supporting the evidence for at least another, more exotic population of magnetars, not born via core-collapsed supernovae. Furthermore, we provide the first constraints on the expected rate of FRBs hupothetically originating from ultra-luminous X-ray (ULX) sources, since some of the galaxies observed during our observational campaign host confirmed ULXs. We obtain an upper limit of 13 yr^{-1} per ULX for the total sample of galaxies observed.

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Fast radio burst generated by coherent curvature radiation from compressed bunches for FRB 20190520B

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The radiation mechanism of fast radio bursts (FRBs) has been extensively studied but still remains elusive. Coherent radiation is identified as a crucial component in the FRB mechanism, with charged bunches also playing a significant role under specific circumstances. In the present research, we propose a phenomenological model that draws upon the coherent curvature radiation framework and the magnetized neutron star, taking into account the kinetic energy losses of outflow particles due to inverse Compton scattering (ICS) induced by soft photons within the magnetosphere. By integrating the ICS deceleration mechanism for particles, we hypothesize a potential compression effect on the particle number density within a magnetic tube/family, which could facilitate achieving the necessary size for coherent radiation in the radial direction. This mechanism might potentially enable the dynamic formation of bunches capable of emitting coherent curvature radiation along the curved magnetic field. Moreover, we examine the formation of bunches from an energy perspective. Our discussion suggests that within the given parameter space the formation of bunches is feasible. Finally, we apply this model to FRB 20190520B, one of the most active repeating FRBs discovered and monitored by FAST. Several observed phenomena are explained, including basic characteristics, frequency downward drifting, and bright spots within certain dynamic spectral ranges.

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Spectro-Temporal Properties of Repeating FRBs and their Relationships

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We survey broadly and deeply the spectro-temporal properties of fast radio bursts observed by earlier studies, focusing deeply on bursts from FRB 20121102A, and, in upcoming work, broadening our focus to bursts from 9 different repeating FRB sources. We investigate 167 bursts from FRB 20121102A spanning frequencies 1-7.5GHz, durations of less than 1 ms to approximately 10 ms, with low and high energies, and with different wait-times. We find from this sample of bursts a strong agreement with the inverse relationship between sub-burst slope and duration and with other predictions made by the triggered relativistic dynamical model (TRDM). For this sample of bursts, we find that the sub-burst slope as well as the 'sad trombone' drift rate are consistent with being in a quadratic relationship with frequency and that both these quantities are inversely proportional to the duration. We also find that the duration decreases with increasing frequency as well as a statistically significant correlation between the sub-burst duration and bandwidth (proportional to $t^{-1/2}$) that is unexpected. No distinct group of bursts in this sample deviated from these relationships, however significant scatter can be seen in measurements. These results demonstrate the consistent existence of relationships between the spectro-temporal properties of bursts from a repeating FRB source. A simple explanation for the inverse relation between the sub-burst slope and duration is an inherently narrowband emission process such as Dicke's Superradiance. In upcoming work we extend this analysis to 175 bursts from nine different repeaters and find consistent agreement across all sources with the sub-burst slope law. This upcoming analysis also suggests that the sub-burst slope and drift rates (measured between multiple components of a burst) are governed by the same relationships. We discuss the implications of these results on our modelling and understanding of the FRB emission mechanism.

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The first Fast Radio Burst at a redshift of 1

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FRBs have been shown to have enormous potential as cosmological probes, provided they can be detected, and their host galaxy redshifts determined to well beyond 1. To date the most distant confident host galaxy redshift is just over 0.6. We present the discovery of FRB 20220610A, a non-repeating FRB localised with ASKAP to a host galaxy system confirmed to be at a redshift of 1.016 with X-shooter on the VLT. The high burst energy (>10^{42} erg) confirms the presence of an energetic burst population at high redshift, boosting the prospects for FRB cosmology in the SKA era.

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Fast radio bursts trigger aftershocks resembling earthquakes, but not solar flares

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The production mechanism of repeating fast radio bursts (FRBs) is still a mystery, and correlations between burst occurrence times and energies may provide important clues to elucidate it. While time correlation studies of FRBs have been mainly performed using wait time distributions, here we report the results of a correlation function analysis of repeating FRBs in the two-dimensional space of time and energy. We find the universal laws on temporal correlations by analyzing nearly 7,000 bursts reported in the literature for the three most active sources of FRB 20121102A, 20201124A, and 20220912A. A clear power-law signal of the correlation function is seen, extending to the typical burst duration (~ 10 msec) toward shorter time intervals. The correlation function indicates that every single burst has about a 10-60% chance of producing an aftershock at a rate decaying by a power-law as t^{−p} with p = 1.5-2.5, like the Omori-Utsu law of earthquakes. The correlated aftershock rate is stable regardless of source activity changes, and there is no correlation between emitted energy and time interval. We demonstrate that all these properties are quantitatively common to earthquakes, but different from solar flares in many aspects, by applying the same analysis method for the data on these phenomena. These results suggest that repeater FRBs are a phenomenon in which energy stored in rigid neutron star crusts is released by seismic activity. This may provide a new opportunity for future studies to explore the physical properties of the neutron star crust. (paper submitted as arXiv:2306.13612)

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Modeling the CHIME/FRB Catalog 1 one-off bursts using frbpoppy

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Fast radio bursts (FRBs) are millisecond-duration phenomena of extragalactic origin. The mechanism of FRBs is still unclear and to some extent, FRB studies are hindered by the limited sample size and non-uniform selection effects between telescopes for a long time. However, things have changed since the CHIME/FRB Catalog 1 was released in June 2021, which contains 536 FRBs, including 474 one-off bursts and 63 bursts from 18 repeaters. This catalog increases the sample size of published FRBs by almost an order of magnitude and is the ever-largest uniform sample, which provides an excellent opportunity to study FRB populations. The frbpoppy, an open-source python package for the population synthesis of FRBs, provides a useful tool with which we can study the underlying intrinsic population as well as various selection effects. By adjusting the input intrinsic parameters and survey parameters, we may be able to find the population closest to observations. In this paper, we conduct a multi-dimensional Markov chain Monte Carlo (MCMC) simulation with updated frbpoppy, comparing the signal-to-noise ratio (S/N), effective pulse width (weff) and total dispersion measure (DM) distributions of simulated FRBs with the CHIME/FRB Catalog 1 one-offs. The number density distribution models, spectral index, luminosity index, the pulse width parameters and DM parameters are constrained simultaneously. We find that the star formation rate (SFR) number density model and delayed SFR with a short delay time are more favored than others from Bayesian Information Criterion (BIC) as well as the side lobe FRBs fraction.

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The Northern Cross Fast Radio Burst project

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The study of Fast Radio Bursts (FRBs) is an extremely active field, where observational results grew dramatically over the last few years, due to the development of new radio telescopes, often capable of surveying larger sky areas and more accurate localizations. In this talk I will provide a status update of the Northern Cross (NC) FRB project. The NC is a 30000 squared metre-collecting area, T-shaped interferometer inaugurated in 1964 to (mostly) carry out surveys of extragalactic radio sources at 408 MHz. I will describe our current effort to equip the NC North-South arm to observe FRBs, including the hardware development, current FRB observations and results, and future perspectives.

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Searching for single-pulses in the HTRU-North survey data: pipeline design, injection tests and first results.

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The High Time Resolution Universe (HTRU) North survey is a major pulsar and transient survey conducted at L-band with the 100m Effelsberg radio telescope that covers the entire northern celestial hemisphere. We describe the setup of the analysis pipeline used to search the HTRU-North survey data for single pulses. This data severely suffers from radio frequency interference (RFI), which will effect the pipeline's detection efficiencies. In order to probe these efficiencies, ~4000 fake fast radio bursts (FRBs) have been injected in a small fraction of the HTRU-North data. The injection parameters used were randomly chosen from distributions such that for each of the four FRB morphologies, identified by Pleunis et al (2021), ~1000 fake FRBs were injected. From these injections, the pipeline's sensitivity to the parameter space of FRBs has been determined, yielding completeness limits for a forthcoming full single-pulse analysis of the HTRU-North data. The investigation of the injection data also provided the first single-pulse search results of the HTRU-North survey. These results include the re-detection of several known pulsars and RRATS and the recovery capabilities of the Fast Extragalactic Transient Candidate Hunter (FETCH) of FRBs of differing morphology types.

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Fast radio bursts from CHIME sidelobes

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CHIME's large field of view in its main lobe has led to a leap forward in the number of sources and in our understanding of FRBs. However, CHIME has a much wider parallel survey with horizon-to-horizon sky coverage provided by its significant sidelobe sensitivity. CHIME's far sidelobes are on average ~500 times less sensitive but have exposure times hundreds of times longer than the

main lobe, so sidelobe-detected events are rare, high-luminosity and nearby counterparts to those detected in the main CHIME/FRB survey. We use an initial sample of 10 sidelobe events to statistically constrain (i) the repetition rate of as yet non-repeating FRBs and (ii) the intergalactic and local dispersion measure of FRBs. As bright, nearby FRB sources are more likely to be detected in the far sidelobes of CHIME, as was the Galactic magnetar SGR 1935+2154, the sidelobe survey offers some of the best prospects for discovering FRB sources in the Milky Way and nearby galaxies. I will discuss these future prospects and plans to leverage this unique capability for rapid multi-wavelength follow-up and characterization of the FRB host environment.

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Deep Synoptic Array-110 Catalog of Fast Radio Bursts and their Host Galaxies

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Fast Radio Bursts (FRBs) are millisecond-duration radio transients with dispersion measures exceeding the maximum possible contribution from the Milky Way, thus indicating extragalactic origins. The arcsecond-scale localizations enabled by modern radio interferometers allow us to associate these enigmatic explosions with their respective host galaxies. The study of the stellar population in the neighborhood of these energetic transients and their delay-time distributions provide critical insight into their progenitor physics. This venture of characterizing host galaxies of FRBs is essential to disentangle the proposed spectrum of formation channels, ranging from young magnetars formed during core-collapse supernovae to binary neutron star mergers in early-type galaxies. Historically, such statistical endeavors have played a crucial role in unveiling the nature of progenitors of several transients, such as gamma-ray bursts and supernovae. The Deep Synoptic Array-110 (DSA-110) has been in the science commissioning phase since early 2022 and has successfully discovered and localized 30+ FRBs. In this talk, we present our insights from the DSA-110 catalog of FRBs and their host galaxies. We use our reliable host identifications to study the derived properties and star formation histories of host galaxies. Further, we present our constraints on the delay-time distribution and discuss the implications on FRB progenitors.

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FRBGUI: A graphical interface for analysing FRBs

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Fast radio bursts are observed to have a broad range of characteristics, with a variety of intensities, durations, structures, and spectro-temporal characteristics. The quantity of observations has increased exponentially in recent years and researchers of all backgrounds need appropriate tools for studying and analysing observations. FRBGUI is an open-source graphical user interface primarily used for performing and reviewing spectro-temporal measurements on FRB waterfalls. It is written in Python using an extensible interface library called DearPyGui that features GPU-accelerated rendering, which results in a responsive and performant interface. FRBGUI performs measurements by fitting a model to the 2D autocorrelation function of burst waterfalls, and automatically repeats measurements over a range of Dispersion Measures (DM). Measurements include the frequency, duration, bandwidth, and sub-burst slope of a burst, as well as the drift rate when applicable. The interface allows a researcher to remove channels contaminated by RFI, separate bursts with multiple components, subsample waterfalls, and prepare initial fit guesses before measurements. Due to the nature of FRBGUI, it is easily extensible and can expose interfaces to other software packages developed by the FRB community. FRBGUI is in an early stage of development and upcoming work will add convenience wrappers for loading different data formats, alternative model formulations to optionally fit on the waterfall directly and improved documentation. In its current state, FRBGUI has already been used for multiple studies on FRBs. We intend for FRBGUI to be a broadly useful tool for the FRB community as well as an effective tool for introducing researchers of any level to FRB analysis. Hosted on github at https://github.com/mef51/frbgui, FRBGUI is freely available and open to contributions.

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Real-time injections of simulated FRBs for the NSM-powered GMRT

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While the rate at which FRBs are being detected has gone up at a startling pace, the localisation of these events to their respective host galaxies has not. This is usually attributed to the often one-off nature of these events, and to the large FoVs of the survey instruments. A possible solution is to use interferometers, which can offer arcsecond to sub-arcsecond localisations. However, they are limited by their narrow FoVs. Many interferometers around the world have turned to establishing commensal surveys (for instance, the realfast survey at the VLA, and CRAFT at the ASKAP), wherein objects of interest are searched for whenever the telescope is operational. This helps compensate for the reduction in detection rates by increasing the survey's sky coverage and integration time. Such surveys require a dedicated backend that analyses data in real time. The GMRT is currently constructing such a backend, funded by the National Supercomputing Mission (NSM). It will be capable of forming and processing 2000 post-correlation phased-array beams over almost the entire frequency range of the GMRT (300 to 1460 MHz), in real time. In order to test the pipeline for this project end-to-end, we are building a real-time injection system for simulated FRBs. It will be able to inject FRBs into both beamformed intensity data and voltage time-series data. While the former has been demonstrated previously for both the UTMOST and the ASKAP, the latter has not. Injecting FRBs into antenna-based voltage time-series data will allow us to place them at particular sky positions, enabling the testing of both the detection and localisation pipelines simultaneously. In this talk, we will describe these and other unique capabilities of our injection system. We will also highlight the detection and classification capabilities of a proof-of-concept multibeam setup at the GMRT.

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Constraining FRB progenitors & emission mechanisms through multi-wavelength observations

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Follow-up observations are crucial to our understanding of fast radio bursts (FRBs), and have enabled studies of their host galaxies and persistent counterparts. As FRB localizations become routine, multi-wavelength simultaneous & post-burst observations will allow us to begin to constrain and characterise the progenitor and the emission mechanisms powering FRBs. In this talk, I will present recent theoretical & observational work undertaken to predict optical and radio counterparts to FRBs in magnetar and neutron star merger progenitor frameworks.

In the former, I will discuss our post-burst observations of FRB 200428 from Galactic magnetar SGR 1935+2154, which provides evidence against the afterglow expected within the synchrotron maser shock model. In the latter, I will briefly discuss a new mechanism for producing FRB-like bursts in neutron star mergers, before detailing prospects for detecting gravitational wave, kilonovae and radio afterglow counterparts. I will conclude by presenting stringent new optical constraints on the association between GW190425 and FRB190425.

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The Stochastic Nature of Repeating FRBs

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Fast Radio Bursts (FRBs) are enigmatic, short-duration bright transients in the radio band with an unknown origin. The Five-hundred-meter Aperture Spherical Telescope (FAST) boasts unparalleled sensitivity, making it uniquely advantageous for studying repetitive FRBs. Here, we present FAST's observations of two repetitive FRBs, namely 20201124A and 20220912A, detecting the highest and second-highest event rates of FRBs ever recorded. Furthermore, we offer a detailed analysis of the energy and polarization properties of these two FRBs, shedding light on the origin of circular polarization in FRBs. Additionally, we introduce a novel method to quantify the randomness and chaotic nature of physical phenomena, enabling a comparison of repetitive FRBs with other physical processes in the same phase space. We hope these findings pave the way for further exploration and understanding of these fascinating cosmic phenomena.

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Unraveling spectro-temporal features of Fast Radio Bursts: Insights from simulations and scattering analysis.

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Fast radio bursts (FRBs) are highly energetic, short-duration transients of mostly cosmological origins. They are classified based on periodicity (repeaters and non-repeaters) and energetics. Repeating FRBs follow the sub-burst slope law consistent with the transformation of an intrinsically narrowband process into a wide-band emission through relativistic motions. A progenitor model explaining all these features is yet to be discovered. Hence, there is a heavy reliance on finding correlations between the observed spectro-temporal features to understand the source dynamics. For example, the sub-burst slope law is an inverse relationship between the frequency-normalized sub-burst slope and duration, where the scaling between the two is governed by the system parameter "A"[Chamma et al.(2023)]. The value of this parameter lies between $0.07 \leq A \leq 0.17$, as seen from a survey of repeating FRBs. This variance in A-values between different FRBs appears to be rooted in the physics of emission. However, observations can be skewed by propagation effects such as scattering. To understand these attributes of FRBs, we simulate bursts using a superradiance emission model, an inherently narrowband process. We then apply the Time Relativistic Dynamical Model introduced by Rajabi et al. (2020) to obtain simulated bursts homologous to the observed FRBs. From here, we convolve the spectrum with different scattering source signals causing a frequency-dependent profile variation. We demonstrate that our simulated bursts can reproduce the observed relations, mainly the sub-burst slope law, which allows us to define the A-parameter within the scope of our model. We also document the effects of scattering and noise on these spectro-temporal relations. Finally, we reveal how this analysis helps us in our understanding of the source and medium environments.

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Two-Screen Scattering in CRAFT FRBs

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Temporal broadening is a commonly observed property of fast radio bursts (FRBs), associated with turbulent media which cause radiowave scattering. Similarly to dispersion, scattering is an important probe of the media along the line of sight to an FRB source, such as the circum-burst or circumgalactic mediums (CGM). Measurements of characteristic scattering times alone are insufficient to constrain the position of the dominant scattering media along the line of sight. However, where more than one scattering screen exists, Galactic scintillation can be leveraged to form strong constraints. We quantify the scattering and scintillation in 10 FRBs with 1) known host galaxies and redshifts and 2) captured voltage data enabling high time resolution analysis, obtained from the Commensal Real-time ASKAP (Australian Square Kilometre Array Pathfinder) Fast Transient survey science project (CRAFT). In this talk I will demonstrate the potential of high resolution CRAFT FRBs as probes of Galactic and extragalactic scattering media, presenting three cases where we find strong evidence for scattering by two screens and four cases displaying a lack on scintillation in tension with current models.

23

A new efficient and accurate de-dispersion algorithm for fast transient searches

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Efficient and accurate de-dispersion algorithms are critical for fast transients search pipelines. The Fast Dispersion Measure Transform (FDMT) algorithm (Zackay et al. 2014) is a popular algorithm employed by some of the leading FRB surveys currently. I'll discuss the limitations of the FDMT algorithm, and characterise the loss in the Signal-to-Noise ratio (S/N) recovery for different pulse morphologies. Additionally, I'll be presenting a new generalised implementation of the FDMT algorithm, called the Efficient Summation of Arbitrary Masks (ESAM), which promises ~100% recovery of the S/N for all desired and arbitrary pulse morphologies. I'll discuss the performance and the computing cost associated with the algorithm and compare it with other existing algorithms in use currently.

24

The first commensal detection of HI and an FRB, and follow-up results

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While analysis of localised FRB host galaxies typically focuses on the stellar component, neutral hydrogen (HI), traced through the 21-cm transition with radio telescopes, informs us on the gas content of galaxies. The HI distribution can reveal to us the history of the galaxy, such as merger events that may not be evident from the stellar information alone. This is an important consideration for understanding the environments of FRBs and their progenitors. We report on HI follow-up of FRBs identified by the CRAFT survey team, including the first commensal detection and localisation of FRB 20211127I, and the detection of HI emission in the FRB host galaxy. Follow-up observations with MeerKAT of other hosts include evidence for an intervening halo along an FRB sightline. MeerKAT follow-up of FRB 20211127I also confirms that the HI intensity map and spectrum is remarkably normal –unlike any previous detection of HI emission in an FRB host, complicating the previous picture supporting a 'fast channel model'for FRB progenitors.

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A LOFAR view of FRBs: Unveiling a second FRB source seen at 150 MHz and developing a high-cadence imaging technique for FRB localization.

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Low-frequency detections of FRBs provide us with important constraints on free-free absorption and other propagation effects in the local environment of the progenitor. Previously, the periodically repeating FRB 20180916B was the first source detected at 110-188 MHz by the LOFAR telescope, making it the lowest-frequency detection of an FRB to date. We have now detected a second FRB source, FRB 20190212A, at 150 MHz. I will report constraints on the scattering timescale, provide upper limits on absorption in the source environment, and discuss the frequency-dependent burst bandwidth of this and other repeaters (with consequences both for understanding FRB emission and detectability). Unlike FRB 20180916B, the burst from FRB 20190212A does not show significant

depolarization at 150 MHz and has a near-zero Faraday rotation measure, providing more evidence for a clean source environment. Additionally, we have been testing a 'fast imaging' technique that produces high-cadence (10-ms) images using the international LOFAR stations. I will present tests of this technique on a pulsar observation. We aim to use this LOFAR observing mode to discover and localize a population of ultra-low-frequency FRBs at sub-arcsecond angular resolution.

26

Dense forests of microshots from the hyperactive repeater FRB 20220912A - plus, a milliarcsecond localisation

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A few repeating fast radio burst (FRB) sources are hyperactive. FRB 20220912A is one such repeater; it was discovered by CHIME/FRB in the last quarter of 2022 as it entered a high activity period. During this time, we detected many hundreds of bursts as part of our FRB monitoring campaign on the Nançay Radio Telescope, called ECLAT (Extragalactic Coherent Light from Astrophysical Transients). I will report on three extremely bright bursts detected from FRB 20220912A as part of the ECLAT campaign. These detections are further enhanced by the excellent time resolution (16 µs), bandwidth (512 MHz) and dynamic range (32 bit) of the NRT data. Additionally, we have overlapping raw-voltage observations from the Westerbork RT-1 25-m dish, enabling us to probe even finer time and frequency scales. In these bursts, we see dense forests of dozens of clustered microshots, each lasting ~ 10 µs. Some of these shots exceed a S/N of 1000; very few FRBs with such high S/N have been studied at this time resolution. Using the microshots to correct for dispersion, an additional residual drift is still present in wider sub-burst components. We propose that the bursts are superpositions of two emission types: broadband microshots and more diffuse, drifting emission. We discuss potential analogies that can be made with solar radio bursts. Furthermore, using over a hundred bursts detected with the European VLBI Network, as part of the PRECISE programme, we present a milliarcsecond localisation of FRB 20220912A that will enable detailed studies of the local environment at ultra-high angular resolution.

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Probing the low-frequency emission of FRBs with the LOFAR Tied-Array All-Sky Survey

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FRBs can be rendered undetectable at low frequencies due to scattering in the intervening medium or a spectral turnover, either intrinsic to the emission mechanism or due to propagation effects in the circum-burst environment. Although emission from two repeating FRB sources has been detected in the low-frequency range below 300 MHz, it is as yet unclear what fraction of FRB sources emit in this frequency range. In order to develop a better picture of the low-frequency emission of FRBs, we searched archival observations made with the Low Frequency Array (LOFAR) telescope at the location of 505 FRB sources. These sources were discovered with the Canadian Hydrogen Intensity Mapping Experiment telescope (CHIME) in the frequency range of 400-800 MHz and include 45 repeating FRBs and 460 apparent non-repeaters. The observations that we searched are each an hour in duration and were conducted as part of the LOFAR Tied-Array All-sky Survey (LOTAAS) in the frequency range of 119-151 MHz. We did not detect any FRBs in our search. Based on the non-detection, we determine that FRBs (at least from the CHIME/FRB sample) have a reduced repetition

rate at low frequencies, even after accounting for the reduced burst detectability due to scattering. Assuming that the low repetition rate is due to free-free absorption in the circum-burst environment, we place constraints on the electron density and temperature in the environments of highly active repeating FRBs. I will describe our search strategy, discuss the resulting constraints on the frequency-dependent repetition of FRBs and their circum-burst environments and present rate predictions for future low-frequency FRB searches.

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Zooming in on the first-known repeating fast radio burst source and its putative hyper-nebula

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FRB 20121102A is the first-known repeating fast radio burst source; it was localised to a low-metallicity dwarf galaxy at a distance of about 1 Gpc. Using the European Very-Long-Baseline Interferometry Network (EVN), it was shown that FRB 20121102A is co-located with a persistent radio source (PRS) to within < 12 milliarcseconds (< 40 parsec projected separation). The PRS itself is constrained to have a size < 0.7 parsec, which is less than half the size of the Crab nebula. The extreme and varying Faraday rotation measure of the bursts ($\sim 10^5$ rad m^{-2}) indicates that the FRB source is embedded in an extreme magneto-ionic environment. Together with the PRS, this suggests that FRB 20121102A is powering a hyper-nebula which is half a million times more luminous than the Crab nebula. Tens of FRBs have an unambiguous localisation to their host galaxy. However, an association with a compact PRS (unrelated to star formation) remains rare: only two FRB sources (FRB 20121102A and FRB 20190520B) have a confirmed association. Here we present a follow-up study of FRB 20121102A and its associated PRS. In recent EVN observations, we have detected 7 bursts from FRB 20121102A. Using much better uv-coverage compared to previous observations, we show that the FRB source and the PRS are co-located to within < 3 milliarcseconds (< 10 parsec projected separation). By combining data from 2016 and 2022, we also place constraints on the proper motion of the FRB source and find that the brightness of the compact PRS has remained roughly constant over a span of > 6 years. These results constrain models in which the PRS is a hyper-nebula powered by a young magnetar; we also discuss the possibility that FRB 20121102A is an accreting neutron star or black hole.

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Probing the highest-energy bursts from hyperactive repeating FRB sources

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Fast radio bursts (FRBs) can be divided into two populations, repeaters and (apparent) non-repeating sources. Repeating sources show a wide range of activity levels, with only a few being hyperactive: i.e., consistently active for weeks to months and producing dozens to hundreds of bursts per hour. When they're bursting, these hyperactive repeaters account for a significant fraction of all observed FRBs. High activity levels, in combination with high-cadence monitoring, allow us to map the burst energy distribution across 6 orders of magnitude, including the rarest and highest-energy bursts that can be generated. FRB 20220912A is the most recent hyperactive repeater discovered and therefore an excellent source to probe the full range of the energy distribution. Since its discovery we have observed this repeater for more than 2200 hours over the span of 5 months using the 25-m class

radio telescopes in Westerbork, Stockert and Toruń. Our high-cadence observing campaign yielded the detection of more than 150 high-fluence bursts (10 Jy ms to >2500 Jy ms) at both 300 MHz and 1.4 GHz (though never simultaneously in both bands). We can compare this newly observed sample of high-fluence bursts from FRB 20220912A with our previous high-cadence campaign that targeted FRB 20201124A for 3500 hours. I will discuss the burst energy distributions of these two hyperactive repeaters, focusing on the implications that their high-energy bursts have for understanding the relation between repeaters and (apparent) non-repeaters.

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VLBI observations with the first CHIME/FRB Outrigger

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The CHIME/FRB Outriggers project will add hundreds of sub-arcsecond FRB localizations to the existing sample of localized FRBs using very long baseline interferometry (VLBI). I will present an update on the status of the VLBI array, mainly focused on observations of bright continuum sources, pulsars, and FRBs using the Canadian Hydrogen Intensity Mapping Experiment (CHIME) and KKO, the first of CHIME's three FRB outriggers. KKO provides an angular resolution of ~1"along one dimension; the resulting improvement in angular resolution over the CHIME/FRB baseband localization alone enables us to robustly associate host galaxies with our one-off bursts.

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Current status of the petabyte project

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Fast radio transients like pulsars, rotating radio transients (RRATs), and fast radio bursts (FRBs) provide unique probes to study the interstellar medium, the intergalactic medium, and the inter-cluster medium, and for cosmological applications. Pulsars, and in particular those classified as RRATs, can also be used for understanding neutron star populations and extreme emission physics. Past deep searches for these phenomena have encompassed many hours on-sky and covered large sky regions, but due to differing processing software and analysis tools, these searches have been non-uniform. The petabyte project (TPP) is a large-scale project that uniformly reprocesses petabytes of archival data from multiple legacy surveys spread across a wide range of radio frequencies and telescopes. The project aims to homogenize the search using a single search pipeline based on Heimdall and the machine learning classifier Fetch. We aim to not only systematically characterize the completeness of past surveys to one-off transient events but also discover many previously undiscovered pulses and bursts. TPP will form a robust catalog of FRBs, RRATs, intermittent pulsars, and more discovered across multiple frequencies and telescopes. Upon its completion, TPP's searches will provide frequency-dependent event rates above a well-characterized completeness threshold. TPP will also maintain a public database with the necessary metadata and detection information. We also aim to address the several computational challenges that arise with the handling of petabytes of data. This talk will focus on the current status of the TPP processing, including the completeness assessment of current surveys.

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The Dispersion Measure Contributions of the Cosmic Web

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The distribution of the Universe's baryons is informed by many processes. The resulting large-scale structure, the Cosmic Web, is often classified into sub-structures, e.g. halos, filaments, and voids.

As fast radio burst (FRB) dispersion measures (DMs) encode information about the ionised matter which lies along their sightlines, the FRB community is increasingly investigating FRB DM contributions. The cosmological DM component is of particular interest: its average over many FRBs on many sightlines has been used to independently calculate cosmological parameters, and weigh the Universe's baryon content at low redshifts; its individual value varies between sightlines, being sensitive to sightline-specific structures, ionised and diffuse matter fractions, and thus, AGN feedback processes. It has been shown that FRB constraining power is limited by this sightline-to-sightline variance, and that low-DM sightlines may prove best for constraining cosmological parameters.

Using the IllustrisTNG cosmological hydrodynamic simulation, we have calculated electron densities, classified large-scale and collapsed structures, and traced FRB sightlines through the Cosmic Web. We combine this information to investigate FRB DM contributions attributed to halos, filaments, voids, and collapsed structures. We find that the filamentary portion of the cosmological DM dominates, comprising 70 - 80% of the total out to z=5. Halo and filamentary environments cause the majority of sightline-to-sightline variance; voids are more homogeneous environments, and thus potentially form better sightlines for probing cosmological parameters. We find that the average number of intersections between FRB sightlines and collapsed TNG structures rises from ~2 at z=1 to ~12 at z=5. While our FRB - TNG structure impact parameter measurements are consistent with galaxy-intersecting FRBs discussed in past literature, the DMs we calculate for TNG intersections appear lower than the average ~90pc/cc excess previously derived for observed events.

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Persistent neutrino counterparts to Fast Radio Bursts

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'Hypernebulae' are inflated by accretion-powered winds accompanying hyper-Eddington mass transfer from an evolved post-main sequence star onto a black hole or neutron star companion 1. It has been suggested that some fast radio bursts (FRBs) may be powered by such short-lived (decades-millenia), jetted, accreting engines 2, and the surrounding hypernebula could generate persistent

radio emission and contribute large and time-variable rotation measure to the bursts. Hypernebulae can be discovered independently of an FRB association in radio surveys, such as VLASS, as off-nuclear point sources whose fluxes can evolve significantly on timescales as short as years, possibly presaging energetic transients from common-envelope mergers. The ions accelerated at the hypernebula termination shock can generate high-energy neutrinos via photohadronic (pγ) interactions with the disk thermal and Comptonized nonthermal background photons. Although detecting neutrino emission associated with the ms-duration bursts themselves is untenable, the persistent radio counterparts of some FRB sources, if associated with hypernebulae, could contribute to the high-energy neutrino diffuse background flux. If the hypernebula birth rate follows that of steller-merger transients and common envelope events, their volume-integrated neutrino emission could explain ⊠25% of the high-energy diffuse neutrino flux observed by the IceCube Observatory and the Baikal-GVD Telescope [3].

1 https://ui.adsabs.harvard.edu/abs/2022ApJ…937….5S/abstract
2 https://ui.adsabs.harvard.edu/abs/2021ApJ…917…13S/abstract
[3] https://ui.adsabs.harvard.edu/abs/2022arXiv221211236S/abstract

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The molecular gas kinematics in the host galaxy of the non-repeating FRB180924B

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Fast radio bursts (FRBs) are millisecond-duration transients with large dispersion measures. The origin of FRBs is still mysterious. One of the methods to comprehend FRB origin is to probe the physical environments of FRB host galaxies. Mapping molecular-gas kinematics in FRB host galaxies is critical because it results in star formation that is likely connected to the birth of FRB progenitors. However, most previous works of FRB host galaxies have focused on its stellar component. Therefore, we, for the first time, report the molecular gas kinematics in the host galaxy of the non-repeating FRB 180924B at $z = 0.3216$. Two velocity components of the CO (3-2) emission line are detected in its host galaxy with the Atacama Large Millimeter/submillimeter Array (ALMA): the peak of one component (-155.40 km s^{-1}) is near the centre of the host galaxy, and another (-7.76 km s^{-1}) is near the FRB position. The CO (3-2) spectrum shows asymmetric profiles with $A_{\rm peak} = 2.03 \pm 0.39$, where $A_{\rm peak}$ is the peak flux density ratio between the two velocity components. The CO (3-2) velocity map also indicates an asymmetric velocity gradient from -180 km s^{-1} to 8 km s^{-1}. These results indicate a disturbed kinetic structure of molecular gas in the host galaxy. Such disturbed kinetic structures are reported for repeating FRB host galaxies using HI emission lines in previous works. Our finding indicates that non-repeating and repeating FRBs could commonly appear in disturbed kinetic environments, suggesting a possible link between the gas kinematics and FRB progenitors.

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PRECISE and EVN-lite: routinely milliarcsecond localizations of Fast Radio Bursts

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With about one thousand of Fast Radio Bursts (FRBs) discovered, astronomers are still struggling to unveil the common properties among the whole population of FRBs, the existence of different types, or the reasons why a less than a handful of them exhibit a persistent radio source associated to the production of bursts.

Precise localizations of FRBs are of paramount importance to uncover the processes driving these objects and to understand their local environments. Over the past years, the European VLBI Network (EVN) has emerged as a leading tool for conducting precise localizations of FRBs. The unparalleled accuracy and resolution of EVN observations has provided valuable insights into the physical properties of FRBs and their surroundings. The size and separation constraints of the bursts and the associated persistent radio sources narrow down the origin of such sources. Additionally, the use of raw VLBI data allowed us to also go narrower in time, and study the bursts down to the nanosecond scale.
This talk aims to highlight the significance of the achieved localizations and how this information shed light on their origin and surrounding astrophysical conditions.

However, a major limitation in VLBI observations is the available observing time on these facilities, hindering the full realization of large-number of precise FRB localizations. To address this limitation, the PRECISE project has been at the forefront of developing new observing strategies which allowed us to get an increased observing time by using a variable number of EVN antennas upon availability. As a significant advancement, the EVN has now publicly advertised the new EVN-lite observing mode in 2023, offering increased accessibility and reduced time constraints for conducting these kinds of campaigns. We are now expanding the operational capabilities of PRECISE/EVN-lite to unveil more FRB localizations faster, deeper, and with a higher cadence.

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Multi-telescope Green Bank searches for Fast Radio Bursts

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We present the latest results from two fast radio burst (FRB) searches being carried out at the Green Bank Observatory. Using GREENBURST, a back-end on the Robert C. Byrd Green Bank Telescope, we have been collecting data almost continuously for the last four years resulting in the detection of many pulsars and transient signals. We give the latest results of GREENBURST observations, including the discovery and follow-up of one new FRB. Secondly, using the 20-m telescope at Green Bank, we have monitored the starburst galaxy M82 to search for magnetar-like bursts from sources like SGR 1935+2154. While no significant detections of pulses have been made in over 30 days of observing, we have been able to place strong constraints on the rate of radio bursts from M82. We offer some predictions for future searches of M82 and other nearby starburst galaxies which may help constrain the connection between FRBs and magnetars.

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Characterising the persistent radio emission associated with FRB 20190520B with the European VLBI Network

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The exact nature and origins of fast radio bursts (FRBs) are still a subject of ongoing research. However, one intriguing aspect that has emerged in recent studies is the presence of persistent radio sources (PRS) associated with two repeating FRBs. PRSs are compact in size and are co-located with the burst, which makes them distinct from the radio emission caused by star formation in the galaxy. *What is the true nature of a PRS and why they are associated with only a small population of repeating FRBs?* The two FRBs associated with PRSs are among the most active sources discovered in low-mass dwarf galaxies, implying that these may be the characteristics of young and active FRB sources surrounded by dense and magnetised plasma. The European VLBI Network (EVN) continues to play a vital role in understanding the nature of PRS by characterising their properties at the milliarcsecond level. In this talk, I will discuss the findings of radio observations of the PRS associated with FRB20190520B made with the EVN as well as their implications for FRB progenitor models. I will also talk about the luminosity and size of PRSs in relation to known source types and compare the results obtained for the FRB20190520B-PRS with those of FRB20121102-PRS.

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Realfast: the past, present and future

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Precise localization of fast radio bursts (FRBs) is a crucial first step in determining the progenitors of FRBs. Realfast is a commensal fast radio transient search system at the Jansky Very Large Array (VLA). It searches for ~10 ms transients in interferometric images created using fast sampled visibilities. Realfast has been running commensally on most L-,S-,C- and X-Band observations since early 2020, completing over 200 days on-sky. So far, it has discovered one FRB, FRB20190614D, during blind searches and has aided in the follow-up and localization of many repeating FRBs found using other telescopes, like FRB20121102A, FRB20180301A, FRB 20201124A, FRB20180916B, FRB20200120E, and FRB 20190520B. Realfast has recently localized a radio burst near the M31 galaxy. In addition to that, it has also localized around 65 borderline FRB candidates. Deep imaging of the fields of these FRB candidates is underway, looking for potential radio counterparts. It has also identified several new pulsars and unidentified Galactic radio sources. Realfast has opened up a new technique of real-time coherent imaging interferometric search systems, making it an essential tool for the discovery and localization of FRBs. In this poster, we focus on the summary of scientific outcomes from realfast so far and the service its offers as an NRAO product.

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Simulating Plasma Lensed FRB Morphologies and Searching for Coherent Phase Correlations in CHIME baseband data

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Searching for time-lag phase correlations in the electric field of an FRB provides a robust way to detect astrophysical lenses. The radio emission produced by FRB sources is extremely point-like such that some lensing systems can have the emission be spatially coherent even after being bent through multiple lensing paths. We previously reported evidence for one such diffractive scattering system through the detection of coherent phase correlations that were present in the baseband data of an FRB event detected by CHIME/FRB. To study systems like these, we have developed a new simulation toolset using phase preserving ray optics to model FRB morphologies and time-lag correlation signatures from propagating through multiple thin lensing screens. In this talk, I will highlight how we see evidence for coherent phase correlations for a new, possibly plasma lensed event detected by CHIME/FRB and, for this FRB, show how our simulation toolset can be used to both model the time-lag correlations and qualitatively reproduce the complex spectro-temporal morphology of the burst from propagating through a small number of dispersive lensed paths.

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Optical and very-high-energy gamma-ray observations of FRBs with the MAGIC telescopes

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Fast Radio Bursts (FRBs) have remained elusive phenomena, with all observed emissions limited to radio wavelengths. However, several theoretical models suggest that FRB emission may extend beyond the radio domain, potentially encompassing high energy emission. These predictions were strengthen when the Galactic magnetar SGR 1935+2154 displayed a FRB-like emission which was correlated with X-ray bursts. While for most FRBs their far distances may not allow us to detect such emission (due to the sensitivity limits of current observatories), this may be feasible for the closer ones.

The MAGIC telescopes (located in the Canary Islands; Spain) are a pair of ground-based 17-m Cherenkov telescopes able to detect very-high-energy gamma rays (> 0.1 TeV). Furthermore, in addition to detecting very-high-energy gamma rays, MAGIC is also suitable for performing ultra-fast optical observations, capable of strongly constraining FRBs prompt flaring optical emission. Leveraging this capability, we present ongoing efforts to conduct simultaneous observations with MAGIC and radio telescopes within the PRECISE/AstroFlash projects.
We aim to put constraints on the putative optical and gamma-ray emission from FRBs, simultaneous or not with respect to the radio frequencies.

Through the collaborative efforts of the PRECISE project and the MAGIC Collaboration, we seek to shed light on the emission processes of FRBs and advance our understanding on the extent of their emission. Here we delve into the exciting potential for groundbreaking discoveries at different wavelengths, offering a new perspective on the physical processes governing the mysterious realm of Fast Radio Bursts.

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A pulsar-like PA swing from a nearby fast radio burst

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In this talk I will report on a nearby fast radio burst (FRB) detected by the Canadian Hydrogen Intensity Mapping Experiment (CHIME) that displays a nearly 180 degree rotation of its polarization angle over the burst duration. This observation is the first of its kind for an FRB, remarkably similar to the S-shaped evolution commonly seen from radio pulsars and strong evidence for magnetospheric origins of the emission. I will demonstrate how the rotating vector model commonly applied to polarimetric observations of pulsars can be extended to fit the observed PA evolution of this FRB, offering constraints on the magnetic inclination angle relative to the line-of-site despite ambiguities introduced from the source's unknown periodicity. I will end the talk offering general thoughts on the implications of this observation for FRB emission models and how this anomalous event may fit in the broader FRB population.

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A wide-band sensitive probe for periodic activities from repeaters with the uGMRT

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The identification of the repeating nature of an FRB may strongly depend on the instrumental sensitivity. The uGMRT being significantly sensitive compared to the major FRB discovering telescope (e.g. CHIME and ASKAP), it can probe the inferred scaling of repetition rate with fluence in a possibly unexplored regime. In addition, an instantaneous wide frequency coverage of the uGMRT (250-1460 MHz), provides an unprecedented view of burst spectral and polarisation properties to differentiate between various progenitor models as well as discriminate between emission and propagation features. Using uGMRT, we investigate the burst properties, such as wide-band spectral structure, variation of burst rate with time and frequency, duration of the active-window and scintillation timescale at different frequencies, temporal-variation of dispersion measure and rotation measure, of the periodic repeaters like FRB20180916B, which provides an insightful probe to constrain the origin of the FRBs. We observed the repeater FRB20180916B in a wide frequency band of the uGMRT, i.e. $250-1460$ MHz, for a duration of 115 days divided into seven different epochs.

In this presentation, we report the detection of 74 bursts from this repeater in 12 hours of on-source time. This corresponds to a burst rate of 6.2 events per hour, which is much higher than the existing burst rate available in the literature to date. All the detected bursts are within the active phase of this repeater, which allows us to further optimise the active window considering the periodicity of $\sim$ 16.35 days for this FRB. From this repeater, we only detect bursts in a narrow frequency range while observing this FRB in a wide frequency band. Using our findings, we highlight the limited emission bandwidth and the frequency evolution of the downward drifting of sub-pulses, the variation of DM, fluence, and other burst features over the activity phase for this repeater.

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The largest sample of apparently non-repeating FRB polarization properties and a comparison with repeating FRB sources.

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I will present a systematic analysis of the polarization properties for all 134 apparently non-repeating fast radio bursts (FRBs) in the first CHIME/FRB baseband catalog, the largest sample of polarized FRB sources to date. Polarization properties of FRBs encode information about their emission mechanisms and local magneto-ionic environment. However, only the polarization of prolific repeaters has been studied in detail so far. Here, I will show a comparison of the linear polarization fraction and rotation measure distributions between repeaters and non-repeaters, determining whether any population scale differences exist between the two classes. Further, I will present the polarization position angle variability across our full sample and also show estimates of their depolarization due to scattering at 400-800 MHz.

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Constraining the FRB mechanism from scintillation in the host galaxy

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Most FRB models can be divided into two groups, separated by the distance of the emitting region from the central engine. This is the case for magnetar FRB models, as well as other models, e.g., involving accreting black holes. The first 'nearby' group, involves emission at distances of $\leq 10^9$ cm from the source, while the second 'far-away' models involve emission from distances of $\geq 10^{13}$ cm relative to the source. Existing observational analyses provide some clues based on pulse variability and burst durations, but in most cases do not provide definitive arguments for either class. We propose that an interstellar scattering screen in the host galaxy can differentiate between the two classes based on the level of modulations in the observed intensity with frequency, in the regime of strong diffractive scintillation. We show that the diffractive length scale of a host galaxy screen should lie in between the transverse source sizes estimated for the 'nearby' (e.g., magnetospheric) scenario, which are $\leq 10^7$ cm, and for the far-away class of models, which are generally $\geq 10^9$ cm. This dictates the level of spectral flux modulation. We discuss the viability of this method in the presence of interstellar scintillation attributable to the Milky Way and for the case of a scattering screen located in the source's immediate environment, such as the magnetar's wind or a supernova remnant. This method is testable when frequency-based fluctuations seen in FRB data can be confidently linked to host galaxy scintillation. We also suggest a way for selecting the bursts most suitable for this analysis and provide an estimate for the frequency scale on which the flux modulation is to be tested. When such observations are made, our theoretical model can become a robust method to pinpoint which class of models is responsible for these enigmatic and highly energetic bursts.

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Is this FRB repeating? Probability of Event Chance Coincidence for Nonhomogeneous Noisy Spatial Point Processes for CHIME/FRB

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Canadian Hydrogen Intensity Mapping Experiment (CHIME)'s large field of view, wide bandwidth, high sensitivity, and powerful correlator makes it an excellent instrument for the detection of FRBs. As we run our experiment for longer and our number of detected FRBs grows, however, the probability of identifying two or more FRB sources within a typical localization region becomes non-negligible. A question of great importance is then, for a given repeater candidate, what is the probability that each of the bursts in a given cluster are physically unrelated to one another (i.e., that they coincided by chance)? In this project, our collaborative research team is working to develop and predict an estimate of the chance coincidence probability of multiple FRBs in the case of a noisy and nonhomogeneous spatial point process. Such a method has applications in modelling, bias studies, and associations between FRBs and other poorly localized phenomena like gravitational wave events.

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Galaxy groups and clusters illuminated by Fast Radio Bursts

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The FLIMFLAM survey is an ongoing effort to constrain the baryon distribution in the ionized intergalactic and circumgalactic media by spectroscopically mapping FRB foregrounds. The survey will lay novel statistical constraints using the spectroscopic redshifts of the foreground galaxies in ~20 sightlines. While the complete analysis is underway, there are striking individual sightlines that warrant a closer inspection. For instance, we recently published the analysis of four sightlines with relatively large extragalactic dispersion measures (Simha et al., 2023). We determined the source of the excess was equally likely to arise from the host/progenitor environment and foreground structures. We also investigate the foreground contributions in FRB20190520B, which was reported to have an anomalously high host DM contribution. In this talk, I will discuss FRB sightlines in our samples intersecting galaxy groups/clusters and the inferences one can make about the group environments leveraging the FLIMFLAM redshifts.

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The path to detecting Milky Way neutral hydrogen absorption features in FRB spectra

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Fast radio bursts are highly energetic transients that are observed ubiquitously across the sky. The number of FRB sources discovered has reached roughly 750 and is expected to increase significantly over the next few years. Each line of sight to an FRB passes through the ISM of the Milky Way, encountering gas, electrons, and ions along the way. The 21-cm absorption line of neutral hydrogen, which is one of the most abundant chemical species found in galaxies, falls right in the spectral range that FRBs can easily probe. We propose that FRB spectra can yield observational signatures of HI absorption in molecular clouds which are found mostly in the plane of the Milky Way. We show that for low-latitude FRBs, the possibility for a sightline to intercept a molecular cloud is high. Furthermore, the scintillation bandwidth for ISM scattering in the Milky Way is very small at low latitudes, which facilitates the reduction of spectral amplitude modulation resulting from Milky Way scintillation by averaging over the spectral resolution of observing detectors. As such, observations of increasing number of FRBs in the galactic plane, or stacking repeat bursts from active repeaters, such as FRB20121102 and FRB20180916, to reduce noise can help provide an alternate and finer probe of HI in molecular clouds. If host galaxy scintillation bandwidth is also larger than $\sim$ MHz, then the signal may become visible with observational frequency resolution of ~ 10 kHz. We also provide estimates on burst fluences and detector sensitivities needed to confidently extract the absorption profiles. Potential observations of HI would be a step towards extending it to the detection of absorption features from host galaxies, providing information even about unlocalized FRB producing galaxies, or from intervening neutral hydrogen halos at high-redshift, improving our understanding of cosmology.

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Commissioning KKO, the First CHIME/FRB Outrigger Telescope

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The CHIME/FRB outrigger program aims to add VLBI localization capabilities to CHIME, such that FRBs may be localized to tens of milliarcsec precision at the time of their discovery and their host galaxies may be identified. The first outrigger telescope is the k'ni?atn k'l⌧stk'masqt outrigger (KKO), located 66 kilometers from CHIME to allow for arcsec-scale resolution. KKO has been in commissioning since it saw first light in June 2022. In addition to demonstrating the scientific potential of KKO, the commissioning efforts have helped enormously with preparing the next outrigger telescope. In this talk I will discuss the results of commissioning tests at KKO, including measurements of system noise and the RFI environment, tests of system stability and robustness in its remote location, and some results of VLBI cross-correlation with CHIME.

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Search for bursts in finer portion of the data: a comprehensive analysis of FRB sub-banded searches and the reprocessing of the HTRU survey

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Fast Radio Bursts (FRBs) are bright radio transients originating primarily from sources outside our Galaxy. Initially reported in 2006 as a single event, it was only in 2014 that the High Time Resolution

Universe (HTRU) survey, conducted with the Parkes-Murriyang telescope, unveiled the existence of the first population of FRBs.
FRBs typically exhibit durations in the range of several milliseconds, akin to the radio pulsar profiles. However, unlike pulsars, FRBs display a much narrower spectrum, typically spanning from a few dozen to hundreds of MHz.
Current FRB searches utilise matched filtering algorithms on frequency-collapsed time series Stokes I data. While modern backends are equipped with remarkable observational bandwidths, often reaching several GHz, conducting burst searches across the full bandwidth may inadvertently lead to missing certain events. A viable alternative involves performing a sub-banded search, wherein bursts are sought within limited portions of the bandwidth. Notably, this technique has already been proposed and successfully applied, leading to the discovery of faint bursts from the repeater FRB 20190711A.
In this work I will delve into the sub-banded search technique, showing how it can significantly enhance the signal-to-noise ratio (S/N) in the detection process. Additionally, I will present the results of a sub-banded reprocessing of the HTRU survey, yielding a new sample of faint and narrow-band bursts.

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Latest results from a panchromatic campaign on the repeater FRB 20180916B

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Fast Radio Bursts (FRBs) are ms duration and Jy intensity bursts of extra-galactic nature whose origin is not yet assessed. To date FRBs have been observed only in the radio band. On the 28th of April 2020 the Galactic magnetar SGR 1935+2154 emitted two radio bursts closely resembling to the ones produced by FRBs with simultaneous detections in the high-energy band. This unprecedented result places magnetars as plausible FRB sources, for at least a subset of them, and strongly motivates panchromatic campaigns towards FRB known sources in order to find, as in the case of SGR 1935+2154, their counterparts from outside the radio band. Despite their very elusive behaviour an FRB source, FRB 20180916B, shows a periodic trend every 16 days with an active window of 5 days, making it an extremely suitable target for this kind of observations. In this talk I will present the results of a multi-wavelength campaign led by the Sardinia Radio Telescope (SRT), the upgraded Giant Metrewave Radio Telescope (uGMRT) and the Northern Cross (NC) in which we monitored FRB 20180916B between November 2020 and August 2021. In particular I will show the properties of the bursts detected in the radio band and I will discuss how the limits obtained in the other frequencies can constrain the origin and emission mechanism of these enigmatic objects.

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VLBI Calibration of the CHIME/FRB Outriggers

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CHIME/FRB and its three Outrigger telescopes will form a Very Long Baseline Interferometry (VLBI) array, with the goal of localising many hundreds of one-off and repeating FRBs to ~50 milliarcsecond precision. Phase calibration is essential for successful VLBI, and requires removing errors due to ionosphere, clock and instrumental delays. However, calibration is challenging due to the transit nature of our telescopes, which precludes pointing towards known VLBI calibrators. I will discuss the impact of the ionosphere and clock-drift on our localisations, and the calibration techniques we

use to account for them. These include using pulsars as calibrators for our longer baselines and in-beam continuum source calibrators for our shortest baseline.

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Energy functions of fast radio bursts derived from the first CHIME/FRB catalogue

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Fast radio bursts (FRBs) are mysterious millisecond pulses in radio, most of which originate from distant galaxies. Revealing the origin of FRBs is becoming central in astronomy. The redshift evolution of the FRB energy function, i.e. the number density of FRB sources as a function of energy, provides important implications for the FRB progenitors. Here, we show the energy functions of FRBs selected from the recently released Canadian Hydrogen Intensity Mapping Experiment (CHIME) catalogue using the Vmax method. The Vmax method allows us to measure the redshift evolution of the energy functions as it is without any prior assumption on the evolution. We use a homogeneous sample of 164 non-repeating FRB sources, which are about one order of magnitude larger than previously investigated samples. The energy functions of non-repeating FRBs show Schechter function-like shapes at z ⊠ 1. The energy functions and volumetric rates of non-repeating FRBs decrease towards higher redshifts similar to the cosmic stellar-mass density evolution: there is no significant difference between the non-repeating FRB rate and cosmic stellar-mass density evolution with a 1 per cent significance threshold, whereas the cosmic star-formation rate scenario is rejected with a more than 99 per cent confidence level. Our results indicate that the event rate of non-repeating FRBs is likely controlled by old populations rather than young populations that are traced by the cosmic star-formation rate density. This suggests old populations, such as old neutron stars and black holes, as more likely progenitors of non-repeating FRBs.

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Magnetars as FRB Sources: A Case Study of XTE J1810-197

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Fast radio bursts (FRBs) are bright, millisecond-duration pulses, originating from unidentified sources. The dispersion measure (DM) of FRBs strongly suggests an extragalactic origin, however, the underlying emission mechanism and the nature of their sources remain elusive. Several theoretical models have been proposed to explain the emission mechanism behind FRBs, with magnetars emerging as a prominent candidate.

Magnetars are a subclass of neutron stars with an extremely high magnetic field, mainly detected via persistent high energy emission. In addition, some magnetars also show transient radio emission, like XTE J1810-197, the first ever magnetar detected at radio frequencies. Here we will present a study of bright pulses from the magnetar XTE J1810-197. The magnetar XTE J1810-197 has been regularly monitored using the upgraded Giant Metrewave Radio Telescope (GMRT), since its recent outburst in late 2018. This systematic monitoring aims to investigate the dynamic behavior and potential evolution of the outburst and the energetics of the single pulses. In our study of the bright single pulses, we analyze various properties in detail and compare these with the known properties of FRBs. In addition, by looking into the energetics of the bright pulses, our study also seeks to address crucial questions like (1) is it possible that the magnetar J1810-197 could emit a burst with energy comparable to that of the repeating FRBs or to that of the Galactic FRB 200428, and (2) if yes, over what timescales? Our results could also have significant implications for the understanding of the likelihood of FRB-like emission from the galactic magnetar population.

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The CRAFT detection system response to real FRBs

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Cosmological studies with FRBs are sensitive to detection biases. One such effect is a bias against high DM pulses due to DM smearing. Theoretical models accounting for this assume idealised bursts and detection systems. Pulse injection allows for a more accurate characterisation which accounts for algorithmic effects but still assumes an idealised burst structure. In this work, we characterise the response of the CRAFT real-time detection system, FREDDA, to real FRB morphologies with the RFI profile at the time of detection. We take high-time resolution voltages of detected FRBs, redisperse them and inject them into an offline version of FREDDA. We compare these results with pulse injection and theoretical models and determine the impacts of neglecting these effects when determining cosmological parameters such as the Hubble constant.

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General Coordinates Network (GCN): NASA's Next Generation Time-Domain and Multimessenger Astronomy Alert System

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General Coordinates Network (GCN) is a public collaboration platform run by NASA for the astronomy research community to share alerts and rapid communications about high-energy, multimessenger, and transient phenomena. Initially designed for real-time notification of mysterious transients in the late 1990's, Gamma-ray bursts (GRBs), since then it has enabled many seminal advances by disseminating observations, requests for follow-up observations, and observing plans. GCN distributes alerts between space- and ground-based observatories, and thousands of astronomers around the world. With new transient instruments from across the electromagnetic spectrum and multimessenger facilities, this coordination effort is more important and complex than ever. Recently the new GCN system based on Apache Kafka is introduced, which is built on modern, open-source, reliable, and secure alert distribution technologies, and deployed in the cloud. In this talk, we will propose how new GCN system can serve as a real-time alert system for the exciting transients of the decade: Fast radio bursts (FRBs), which necessitates a collaborative community effort for swift follow-up actions and automated cross-correlation with other transients. GCN alert system, an example in the

field of GRBs, can enable the real-time notifications of FRBs and will be valuable resource for the transient's astronomy in the future.

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LPDA Arrays for Localizing Bright Nearby FRBs from CHIME sidelobes

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Over the past 4 years, 10 very bright but extremely rare FRBs were detected in the CHIME far side lobes. These FRBs are statistically ~20 times closer than the typical FRBs detected in CHIME's main lobe. Localizing them to a Galactic source or pinpointing their locations in nearby galaxies precisely will be invaluable for unraveling the nature of FRBs. However, achieving this requires VLBI-quality localisation precision, which CHIME lacks.
To address this limitation we built Log-Periodic Dipole Antenna (LPDA) arrays in two locations: the Algonquin Radio Observatory (3000km west of CHIME) and near Hilo, Hawaii (5000km east-south of CHIME). Each array has 8 small antennas, with a wide field of view covering half of the sky, matching CHIME's side-lobes. The combined sensitivity of each array is enough to detect the brightest of CHIME's side-lobe FRBs through cross-correlation with CHIME. These arrays serve as testbeds and demonstrators of the technology and analysis techniques for BURSTT, a large LPDA array being constructed in Taiwan, optimized to discover and localize a significant number of rare, high-fluence, nearby FRBs.
In my talk, I will present the development and commissioning of these LPDA arrays, as well as our early results.

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The unusual case of the missing Fast Radio Burst host galaxy

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FRB 20210912A is a fast radio burst (FRB), detected and localised to sub-arcsecond precision by the Australian Square Kilometre Array Pathfinder. No host galaxy has been identified for this burst despite the high precision of its localisation and deep optical and infrared follow-up, to 5-σ limits

of $R = 26.7$ mag and $K_{\rm s} = 24.9$ mag with the Very Large Telescope. The combination of precise radio localisation and deep optical imaging has almost always resulted in the secure identification of a host galaxy, and this is the first case in which the line-of-sight is not obscured by the Galactic disk. The dispersion measure of this burst, $\rm DM_{FRB} = 1233.696 \pm 0.006$ pc cm^{-3}, allows for a large source redshift of $z > 1$ according to the Macquart relation. It could thus be that the host galaxy is consistent with the known population of FRB hosts, but is too distant to detect in our observations ($z > 0.7$ for a host like that of the first repeating FRB source); that it is more nearby with a significant excess in $\rm DM_{host}$, and thus dimmer than any known FRB host; or, least likely, that the FRB is truly hostless. We consider each possibility, making use of the population of known FRB hosts to frame each scenario.
The fact of the missing host has ramifications for the FRB field: even with high-precision localisation and deep follow-up, some FRB hosts may be difficult to detect, with more distant hosts being the less likely to be found. This has implications for FRB cosmology, in which high-redshift detections are valuable.

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Statistical study for categorization of population of FRBs

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Fast Radio Bursts (FRBs) are milli-second radio transients of very high intensity. In this study, the radio emitted from each FRB, observed so far, has been estimated from the measured fluence and the luminosity distance. A simple histogram of FRB radio energy emission shows a bi-modality in the distribution, suggesting that FRBs come in two distinct categories. A systematic statistical analysis has been carried out in this work to study the correlations between various physical quantities associated with the FRBs belonging to the two categories. In particular, using the fluence F to study the FRB number counts, one finds that N($>$ F).F$^{-1.5}$ versus F plot displays significant differences for the two categories.

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Searching for second-timescale radio transients with CHIME telescope.

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The Canadian Hydrogen Intensity Mapping Experiment (CHIME) is a transit radio telescope operating across 400 - 800 MHz with a field of view of ~ 200 sq. degrees. The telescope has been

regularly detecting Fast Radio Bursts using the CHIME/FRB system. The sensitivity of CHIME/FRB reduces with larger pulse widths due to the current design of its radio frequency interference (RFI) removal algorithms, making it challenging to detect bursts with widths > 50 ms. Hence, slower duration transients are as-yet unexplored and open parameter space. Possible sources for such radio transients could include flaring stars, compact binaries, radio counterparts of binary neutron star mergers or GRBs. In the talk, I will present our transient search pipeline developed to detect slower duration radio transients (50 ms - 5 seconds) in the CHIME data and discuss the preliminary results obtained from a pilot survey. The pipeline makes use of well-established tools and algorithms such as PRESTO, HDBSCAN and FETCH for RFI cleaning, single-pulse search and event classification. The novel setup is designed from inception to have a built-in system to inject simulated pulses (sampled across DM, fluence and pulse width parameter space) in the real data and recover them using the pipeline. The statistics from the injection system are used to optimise the detection efficiency of the RFI removal algorithm, measure the false alarm rate, and measure the detection completeness of the pipeline. The pipeline will be deployed to detect slow radio transients in the data gathered for the CHIME Slow Pulsar Search project.

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Does elasticity stabilize a magnetic neutron star?

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The configuration of the magnetic field in the interior of a neutron star is mostly unknown from observations. Theoretical models of the interior magnetic field geometry tend to be oversimplified to avoid mathematical complexity and tend to be based on axisymmetric barotropic fluid systems. These static magnetic equilibrium configurations have been shown to be unstable on a short timescale against an infinitesimal perturbation. Given this instability, it is relevant to consider how more realistic neutron star physics affects the outcome. In particular, it makes sense to ask if elasticity, which provides an additional restoring force on the perturbations, may stabilize the system. It is well known that the matter in the neutron star crust forms an ionic crystal. The interactions between the crystallized nuclei can generate shear stress against any applied strain. To incorporate the effect of the crust on the dynamical evolution of the perturbed equilibrium structure, we study the effect of elasticity on the instability of an axisymmetric magnetic star. In particular, we determine the critical shear modulus required to prevent magnetic instability and consider the corresponding astrophysical consequences.

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Deciphering the Origins of Dispersion Measure and Scattering in FRBs with the DSA-110

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We present a multi-wavelength study of the host galaxy and its environment for a Fast Radio Burst (FRB) known as “Nihari”, detected by the Deep Synoptic Array (DSA)-110, a new radio interferometer dedicated to finding and localizing FRBs. Nihari shows a moderately high dispersion measure (DM) of 706 pc cm-3 and a substantial scattering timescale of order 25 ms, indicating a complex intervening medium along the line of sight. We use both multi-slit and single-slit optical spectroscopy from Keck/DEIMOS and Keck/LRIS, respectively, to probe 52 galaxies in the field of the FRB host, all of which were identified previously in legacy data. We also apply neural networks trained on Illustris TNG simulation data to infer the large-scale structure surrounding these galaxies and map out the nodes and filaments towards the host, which lies at z~0.55. We aim to construct a DM budget for the

FRB and identify the main contributors to the DM and scattering. We find that two low-impact parameter neighboring galaxies have halos that likely intersect with the line of sight, and may account for a significant fraction of the scattering. In this talk, we discuss the implications of our results for understanding the scattering effects present in FRBs and their respective DM budgets.

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Connecting FRB Foreground Mapping with Galaxy Feedback Models

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By combining localized FRBs with spectroscopic observations of galaxies in their foreground, the FLIMFLAM project aims to place constraints on the relative fraction of cosmic baryons residing in the diffuse intergalactic medium (IGM) as well as in the circumgalactic media (CGM). I will show, based on cosmological hydrodynamical simulations, that these relative baryon fractions depend sensitively on the galaxy feedback prescriptions implemented in the simulations. FRB foreground mapping thus offers a unique probe of galaxy feedback, especially from AGN activity. I will also describe how the relative baryon distribution affects the cosmological matter power spectrum especially on small scales, potentially being the key to solving the "lensing is low" cosmological tension. I will then provide forecasts how future surveys can make these constraints.

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Resolving new MeerTRAP FRBs in space and time

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In the rapidly evolving field of Fast Radio Bursts (FRBs), host galaxy identification, detailed spectro-temporal analyses and population studies remain essential to identify the nature of the FRB progenitors. The MeerTRAP project at the MeerKAT radio telescope in South-Africa has been looking for galactic and extragalactic radio transients since 2019. Its high sensitivity allows for the detection of faint, highly dispersed FRBs, while the broad frequency coverage in three different bandwidths facilitates the study of their detailed spectral properties. To date, MeerTRAP has found more than forty, so far non-repeating, FRBs.
Within the project, the recently operational Transient Buffer system automatically stores 300 ms of raw voltage data from all 64 meerKAT dishes following the dispersion curve of any newly detected bright FRB. This permits the localisation of one-off FRBs with arcsecond precision, as well as enabling us to obtain coherently dedispersed dynamic spectra with micro-second resolution and polarisation information.
In this talk, I will present the latest MeerTRAP TB-triggered FRBs that we have been able to localise to their host galaxies. These constitute a sample of high-redshift FRBs, which is advantageous to probe the distant Universe and to understand how FRB formation evolves at cosmological distances. In addition, the bursts display complex spectro-temporal structures with micro-second timescales, high linear polarisation fractions and a wide range of rotation measures. Overall, we will consider these structures, and those seen in other one-off FRBs, in terms of a magnetospheric origin.

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Two Scattering Screen Effects on FRBs

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Fast Radio Bursts are known to exhibit scintillation and scattering phenomena , often attributed to the interaction of multiple screens. A common argument is that two screens, when appearing "pointlike" to each other, scintillate on both scales. This condition is commonly invoked to constrain scattering to FRB host galaxies. In this study, we explore this regime through simulations, revealing that host galaxy scintillation persists even with two resolved screens. We also investigate the observable's arising from such a scenario.

The project's primary goal is to understand the appearance of the pulse when the screens resolve each other. The dynamic spectra of the pulse in this context unveil two distinct scales of scintillation, contradicting the argument the scattered image formed by the first screen should be unresolved by the second screen to observe 2-screen diffractive scintillation, commonly used to set an upper limit on the host screen distance from the FRB source.

Our investigation has revealed that as the screens resolve each other , the scintillation pattern changes along the scattering tail, a phenomenon absent when the screens remain unresolved. Our study also shows how specific FRB structures can arise from particular image distributions within the scattering screen. Additionally, we investigate the alterations in observables, such as modulation index, scintillation time scale, and bandwidth, as the screens resolve. And we also explore the number of bursts necessary to generate the secondary spectra to probe the scattering screen.

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Probing the Circumgalactic Medium with Fast Radio Bursts: Insights from the CAMELS Simulations

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The physics of the circumgalactic medium (CGM), the region beyond the disk of a galaxy but within the virial radius, is complex and not well understood. It is essential that we understand the processes and properties of ionized baryons in the CGM because within these processes/properties are encoded formation history, feedback mechanisms of galaxy evolution, and a potentially large fractions of "missing"baryons. In the era of multi-wavelength astronomical surveys, one promising probe is dispersion measure (DM) of fast radio bursts (FRBs), useful for quantifying and locating baryons in the CGM as it is a function of only the electron density distribution. We analyze the Cosmology and Astrophysics with Machine Learning Simulations (CAMELS) simulations, currently comprising over 10,000 state-of-the-art cosmological simulations, and spanning a wide range of astrophysical and cosmological parameters. Using the CAMELS simulation suite, we explore how the implementation of CGM physics impacts the DM of FRBs. We investigate the distribution of DM resulting from varying cosmological (Ω_M, Σ_8) and astrophysical parameters (stellar and AGN feedback), finding that Ω_M and the parameter controlling the strength of supernovae feedback results in significant differences in the distribution of DM. We probe the role and contribution of the CGM to the total DM by measuring the excess DM associated with FRBs interacting with the CGM, comparing the various

CAMELS models. Lastly, we quantify the effect of feedback through the F-parameter (a parameter that inversely scales with strength of feedback). We find that both cosmological parameters are degenerate with F, and the four astrophysical parameters have varying effects with ASN1 and AGN1 having positive correlation with F. Comparing to recent observations, these results are in tension with a majority of the CAMELS-SIMBA models, getting us closer to our goal of a realistic model of the CGM

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Learning about the Fast Radio Burst family through 'identical twins'

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Fast radio bursts (FRBs) are extremely bright short-lived radio transients of unknown origin. More than a thousand FRBs have been detected in the past couple of years thanks to the dedicated search campaigns with sensitive radio telescopes around the world. While a small fraction of FRBs are known to repeat, most of them appear to be one off events. Precise localization of FRBs with radio interferometers has revealed a vast diversity in their host galaxies and the local environments of their progenitors. Bursts properties, such as temporal profile, spectral structure, polarization, of non-repeating as well as repeating FRBs vary over a wide range of parameters. This makes it difficult to constrain the nature of the progenitors and the emission mechanism.
Recently we identified two FRBs, detected by the Australian SKA Pathfinder (ASKAP) telescope in the Commensal Real-time ASKAP Fast Transients (CRAFT) Survey, that show striking similarities in their complex time profiles as well as similar and interesting polarization properties. These 'twin' FRBs, however, have very different dispersion measures and were detected in different parts of the sky. None of them are known to repeat as of now. The surprising resemblances between these two FRBs suggest that there might be a sub-class of FRBs that both these events belong to. The common properties of the 'twin' FRBs also bear unique signatures that provide important clues about the nature of their progenitors.

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Scattering in the host galaxies of a large sample of FRBs as a probe of local environments and a constraint on redshifts

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Disentangling the effects of scattering, dispersion and drifting in FRB signals uncovers clues about the local environment and intrinsic FRB properties. This is more successfully done with the higher resolution afforded by complex voltage (baseband) data: for CHIME this data has 1024 frequency channels from 400-800MHz, and 2.56 microsecond time resolution. Additionally, the higher time resolution of the baseband data, compared with CHIME's intensity data, provides the opportunity to

probe scattering times <0.1ms which was not possible in the first CHIME catalog. If the scattering measured is attributed to the FRB host galaxy, it can be used to constrain host DM values and consequently FRB redshifts. Cordes, Ocker & Chatterjee (2022) showed that for 14 FRBs with measured redshifts a combination of scattering and DM indeed better constrain the FRB redshift than using the DM alone. We apply their method to CHIME's first catalog of baseband data, containing 140 FRBs. I will present the distribution of scattering, host DM and redshifts for this FRB sample. Furthermore, I will discuss the implications of our results for host galaxy associations and our understanding of FRB local environments.

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The discovery, monitoring and modelling of repeating FRB sources from CHIME/FRB

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The CHIME/FRB project has so far discovered over fifty repeating FRB sources in near-daily observations of the northern sky (δ > -11 degrees), which has directly and through targeted follow-up observations led to many advances in our understanding of FRBs. Differences between the duration, bandwidth and dispersion measure distributions of repeaters and apparent nonrepeaters hint at distinct populations. However, it is still possible that all FRBs eventually repeat, as we have not detected a clear bimodality between the repetition rates and upper limits on repetition, although some active repeating sources stand out as anomalous. I will present results from three avenues through which we are improving our understanding of the repeater population: automated discovery of new repeating sources, monitoring the activity of known sources and forward-modelling (population synthesis) of a simulated universe with FRBs.

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Testing source models of FRB 20180916B using polarimetric uGMRT observations

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FRB 20180916B is a singular Fast Radio Burst whose activity window is not only periodic with a 16-day period but also chromatic in that it shifts with observing frequency. The causes of the periodicity and chromaticity are unknown. One way to test proposed models is by studying the polarization position angle (PPA). As part of the ongoing FRB monitoring campaign with uGMRT, we report fifty bursts at 650 MHz, which have been polarization calibrated. Additionally, we also report six bursts at 1100 MHz, which are undergoing calibration. Two of the bursts possess coincident components at 1100 MHz and 650 MHz; such a feature has not been observed before. Recent detections by CHIME/FRB and LOFAR have observed an RM change with time. We compare this trend against our

contemporaneous uGMRT sample and find that the trend is in agreement. We also have additional data that spans beyond the current known detections, which we will search shortly. Detection of bursts from this time would probe the RM trend further than the published measurements. Making use of the PPA, we perform dynamic magnetar model tests as postulated in Li and Zanazzi (2021) to try to explain the periodicity and chromaticity. Furthermore, we apply a PPA fitting code which we developed to solve for the geometry of the dynamical system. Lastly, we perform single burst statistics and compare uGMRT burst population against CHIME/FRB, APERTIF, and LOFAR populations.

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Constraining the distribution of cosmic baryons: the first results from FLIMFLAM survey.

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Abstract: The 'Missing Baryon Problem' has been resolved thanks to recent samples of localised fast radio bursts (FRBs) with measured redshifts, but major questions remain regarding the relative distribution of cosmic baryons in the diffuse IGM vs CGM of galaxies. The ongoing FLIMFLAM project aims to answer these question by mapping the foregrounds of ~20-30 localised FRBs primarily detected by CRAFT/ASKAP and localised by the F^4 collaboration. I will discuss the first data release of the FLIMFLAM survey that includes 8 FRB sightlines. I will present the first measurement of the relative baryon fractions in the IGM versus the CGM.

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Rapid spin changes around a magnetar fast radio burst

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SGR 1935+2154 is the only Galactic source thus far reported to exhibit FRB-like activity. Here I report (on behalf of the NICER magnetar working group) new NICER and NuSTAR X-ray timing results around the October 2022 radio bursts. The unprecedented observational cadence captures extraordinary (and never before reported) rapid spin variations in a magnetar. These timing anomalies bracket the radio bursts. I will also discuss theoretical interpretations of these observations and what it might indicate for the FRB mechanism.

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GMRT Regular Observations Of fast Transients (GROOT)- FRB20220912A: Burst Properties and Morphologies

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FRB 20220912A, a repeating fast radio burst, was in a state of high activity following its discovery last year by CHIME/FRB. During this state, it was localized by DSA. Multiple follow-up observations have been conducted for FRB 20220912A during and after its hyperactive period, but most of them were at L or S-band.

We have been monitoring FRB 20220912A at low frequencies ranging from 300 MHz to 750 MHz using the upgraded Giant Metrewave Radio Telescope (uGMRT). We first observed FRB 20220912A on November 22nd and 24th, 2023 (ATel #15806). On the 24th, we observed simultaneously in two bands of uGMRT (300-500 MHz and 550-750 MHz). After that, we have been monitoring FR20220912A at regular intervals since January 2023. In a total of 11.3 hours of on-source time, our preliminary analysis has yielded over 350 bursts so far.

We will present a detailed analysis of the burst properties, such as variations of dispersion measure, scattering timescale, temporal and spectral width, and rate, with observing frequency and epoch. During all the observations, we recorded baseband data, enabling us to study the microstructure of the bursts and their properties. We shall show the detailed high time resolution morphology of some noteworthy bursts.

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GMRT Regular Observations Of fast Transients (GROOT) - FRB20220912A: Burst Activity Rate, Energetics and Population properties

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Fast Radio Bursts (FRBs) show a diverse range of activity —most FRBs have been observed to burst once, others, the repeating FRBs, have shown sporadic repeats, periodic activity windows (e.g. FRB 20180916B, FRB20121102A) as well as long periods of quiescence interrupted by a period of hyperactivity (e.g. FRB 20201124A). Long-term monitoring and probing variations in activity allow us to constrain various progenitor models for repeating FRBs and could help identify different classes of repeaters based on their activity.

On September 12, 2022, CHIME discovered FRB 20220912A, which exhibited very high activity rates. Follow-up observations from various telescopes were conducted which show activity rates of >100/hr at L-Band. We observed FRB 20220912A using uGMRT, covering frequencies from 300 to 750 MHz (in the simultaneous dual-band mode). During observations in November 2022, we detected about 249 bursts with a total on-source time of 2.35 hours. These detections showed a high activity rate even at low frequencies. Since then, we started a long-term monitoring program with monthly observations from Jan 2023 to Sep 2023. Till now we have detected over 350 bursts in 11.3 hours of observations between November 2022 to July 2023 with preliminary analysis. We will discuss the multi-band detections of the bursts at low radio frequencies with uGMRT and discuss the variation of burst rates, energetics, and FRB activity over the year.

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Automated morphological classification of FRBs using Deep Learning framework

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Fast Radio Bursts (FRBs) display diverse temporal and frequency structures, possibly indicating different origins or emission mechanisms. The detection of numerous FRBs by CHIME and other radio telescopes is expected to increase in the future.To prioritise multiwavelength follow-up observations with ground- and space-based telescopes, a rapid, automated classification system for FRB morphologies is crucial, especially for identifying rare and anomalous events.

We have created a simulation and classification framework for different FRB types. The identified FRB categories include single-component FRBs with broad or narrow-band spectra, multicomponent FRBs, downward drifting patterns in repeaters, and comb-like structures for sidelobe detection.

For classification, we use Deep Learning Models, which have shown better accuracy in image recognition tasks. We trained and optimized the models using the simulated training set and tested them with real data from the CHIME/FRB first catalog. Our preliminary analysis achieved about 50% overall accuracy for the multi-class classification on real data, including low signal to noise ratio events. We'll also discuss other multiclass classification approaches and present our methodology and outcomes. Additionally, we aim to make the code and example data for the framework publicly available to benefit the scientific community.

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GMRT Regular Observations Of fast Transients (GROOT)- FRB20220912A: Polarization Analysis

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Fast Radio Bursts (FRBs) are bright, millisecond-duration radio transients, which are mostly extragalactic in origin. While there are many proposed emission mechanisms, there are few, if any, constraining observations that can identify specific origins. The polarization properties of bursts can provide stringent constraints on the emission mechanisms as well as on the local and intervening magneto-ionic medium. The small subsample of FRBs with measured polarization shows significant linear polarization with some FRBs showing a circular polarization component. Following up repeaters and studying their variation of polarization properties has been very useful to match several predictions of progenitor models to rule out emission models.

FRB 20220912A is discovered by the Canadian Hydrogen Intensity Experiment (CHIME) -FRB collaboration (ATel #15679). We have followed up FRB 20220912A with uGMRT band 3 (300-500 MHz) and band 4 (550-750 MHz) starting from November 22nd, 2022 to September 24th, 2023 (time allotted in uGMRT cycle 44) with a cadence of roughly 3 weeks. From an exploratory analysis of the first few epochs, we have detected at least 350 bursts so far (ATel #15806 containing the first 60 bursts detected with uGMRT band 3 and 4).

We will present polarization measurements of these detected bursts. We will explore the variability of Rotation Measure (RM) and fractional polarization between each epoch and also from burst to burst. We will also explore the depolarization effects by comparing higher frequency (650 MHz) polarization measurements with those at lower frequency (400 MHz). We will discuss the implications of these results in the context of different emission mechanism models'predictions.

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GMRT Regular Observations Of fast Transients (GROOT) - FRB20220912A: Scintillation and Scattering Properties

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Repeaters are the most promising candidates to unveil the mystery of the origin of Fast Radio Bursts (FRBs) as they provide a large sample of bursts. Due to the inhomogeneous and turbulent plasma medium in the vicinity of the source region and along the line of sight, FRBs often exhibit multipath propagation effects, i.e., scattering and scintillation. Therefore, studying the scattering and scintillation properties and their evolution with time and frequency helps to characterize the circumburst and intervening media. We have been monitoring the hyperactive repeater FRB20220912A since November 2022, with the upgraded GMRT (uGMRT) to study its properties at low frequencies. We have detected tens of bursts sufficiently bright to study its scintillation and scattering properties. The analysis has been carried out using the baseband data with reduced temporal and spectral resolutions of ~ 3 kHz and ~ 163 µs, respectively. The measured scattering time scale is 0.16 ms at a reference frequency of 1 GHz while the scintillation bandwidth is 196.1 kHz, much lower than the scintillation bandwidth corresponding to the measured scattering timescale. This indicates that there are two different screens along the line of sight individually responsible for the scattering and scintillation. We have put a stringent constraint on the upper limit of the location of the dominant screen using the simultaneous observations of scintillation and scattering. Our 650-MHz uGMRT results are roughly consistent with the findings from FAST 1.4-GHz observations of R117 (Wu et al., 2023). Here we report the results of the scintillation and scattering properties of the repeating FRB20220912A from the long-term monitoring.

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Constraining Cosmological Parameters through a Spatial Cross-correlation between Fast Radio Bursts and Galaxies

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Fast radio bursts (FRBs) are a newly emerged transient phenomenon that holds great promise for investigating cosmological parameters. However, their potential is hindered by the limited number of localized FRBs and the absence of redshift measurements for individual FRBs, presenting a significant challenge.

To address this, we propose a cross-correlation method between FRB and galaxy catalogs to measure statistical redshifts of FRB samples without FRB localization. To demonstrate the feasibility of this method, we create mock catalogs of non-repeating FRBs by applying the capabilities of the (i) Square Kilometre Array (SKA) and (ii) Bustling Universe Radio Survey Telescope in Taiwan (BURSTT); and catalogs of galaxies with the capabilities of (i) Sloan Digital Sky Survey (SDSS) and (ii) Dark Energy Spectroscopic Instrument survey (DESI), respectively, to cosmological simulations of galaxy formation and evolution.

Through cross-correlation analysis, we obtain valuable statistical redshift information and employ two approaches to estimate cosmological parameters. Firstly, we explore the intergalactic dispersion measure as a function of the statistical redshift for key insights. Secondly, we discuss the possible usage of the luminosity-duration relation of non-repeating FRBs, treating FRBs as standard candles. We present that once we measured the dispersion measure, observed fluence, and intrinsic duration of FRBs, we can effectively constrain cosmological parameters.

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Deciphering FRB Progenitors: A DM Distribution Study with CHIME

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The nature of fast radio burst (FRB) progenitors remains elusive despite significant progress in FRB studies. We analyze the dispersion measure (DM) distribution from the CHIME/FRB Catalog 1, a homogeneous sample one order of magnitude larger than previous works. Our model considers repeating sources, taking into account a power-law energy function, non-Poissonian wait-time clustering, CHIME observing setups (including declination-dependent exposure time history and number of observing sessions), redshift evolution of source densities, and stochastic DM contributions from the Milky Way, intergalactic medium, and host galaxies. Importantly, we simultaneously fit models to both apparent non-repeaters and repeaters across six sky directions, departing from previous works focusing solely on repeating FRBs. In this presentation, we will discuss parameter inference, with a particular focus on the implications of potential significant deviations of FRBs from cosmic star

formation history. Our results will be compared with recent studies on host galaxies, shedding light on the perplexing nature of FRB progenitors.

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Host Association for CHIME/FRB Bursts in the First Baseband Catalog

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I will present host association and characterization analysis for nearby FRBs in the first CHIME/FRB baseband catalog. From July 25, 2018 to July 1, 2019, CHIME/FRB detected over one hundred FRBs with saved raw voltage “baseband” data. With baseband data, CHIME can localize bursts to subarcminute precision, enabling unambiguous host galaxy identification for nearby FRB sources. Host identification offers a crucial avenue toward understanding FRB origins via multiwavelength characterization of host galaxy properties, which yields constraints on the age and type of the FRB progenitor. I will discuss our association method, as well as how the properties of newly identified hosts situate within our current understanding of FRB host galaxy demographics, and what they ultimately tell us about FRB progenitors.

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Morphology study of 140 FRBs at microseconds timescale

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In this study, we conduct a morphological analysis of 140 Fast Radio Bursts (FRBs) at microsecond resolution in the first CHIME/FRB baseband catalog. Our aim was to explore the complex time and frequency structures exhibited by FRBs, which may be obscured at coarser resolutions. Leveraging the dataset, we coherently dedisperse bursts and measure their spectral and temporal properties using Fitburst, a least square optimization fitting routine by CHIME/FRB. We study the distribution of DM, intrinsic width, scattering timescales, and bandwidths for our FRB sample, along with correlation analyses, e.g. DM vs scattering, rotation measure vs scattering etc., to gain insights into their local environments. We explore quasi-periodicities among multi-component bursts and the effects of plasma lensing on exotic morphologies. Additionally, we search for microstructures in the brightest bursts, examining the phase space of ultra-fast FRB emission and potential luminosity-microstructure connections. Relationships between width, DM, and brightness were studied for fluence-distance dependence. This comprehensive investigation represents the largest study of FRBs as a population at such high time resolution

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Selection bias in observing the host galaxies of fast radio bursts

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The origin of fast radio bursts (FRBs) is among the foremost questions in modern astronomy. One of the most promising approaches to answering this question lies in studying the host galaxies and local environments of FRBs. Previous studies have utilized various FRB host demographic analyses to identify potential formation channels of FRB progenitors. However, these analyses have overlooked the impact of optical and radio selection effects, potentially influencing the interpretation of their findings.

In this talk, we report on observational biases present in the sample of the Commensal Real-time ASKAP Fast Transients Survey (CRAFT) and Deep Synoptic Array (DSA)-110 localized FRB host galaxies. The sample we employed in our study consists of 25 FRB host galaxies discovered and localized by the aforementioned surveys, with r-band magnitude < 21 AB mag. The noted biases likely stem from unaccounted radio selection effects, leading to a substantial number of FRBs being missed, especially those whose sight-lines traverse highly turbulent and dense regions within their host galaxies. Furthermore, the implications of these biases would likely go beyond FRB host demographics as they may impact the use of FRBs localized by existing and upcoming untargeted surveys, such as the Canadian Hydrogen Intensity Mapping Experiment Fast Radio Burst Outriggers, CRAFT, DSA-2000, and Square Kilometer Array, to understand the cosmological evolution of FRB sources.

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Unveiling the Most Promising Formation Channel of FRBs Using Local Universe Bursts

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The origin of fast radio bursts (FRBs) remains an enduring enigma in contemporary astronomy, even after 17 years since their serendipitous discovery. A plethora of models has been proposed to shed light on their origins, encompassing both cataclysmic and non-cataclysmic formation channels. Within the non-cataclysmic category, the debate persists on whether the majority of FRBs are promptly formed after the death of their progenitor main sequence star or arise from recycled compact objects.

In this talk, I leverage currently available observational data to address three pivotal questions:

1. What are the prospects of detecting FRBs originating from proposed cataclysmic channels?
2. Is there a single dominant FRB formation channel, governing these enigmatic bursts?
3. If a dominant channel does exist, can it explain the observed diversity among FRB host galaxies and their local environments?

To address these probing questions, I use a sample of approximately two dozen local Universe FRBs (z < 0.1), many of which have been detected by the Canadian Hydrogen Intensity Mapping Experiment Fast Radio Burst (CHIME/FRB) Project. Our analysis provides compelling evidence that core collapse supernovae are likely the dominant formation channel of FRB progenitors. Finally, this finding has noteworthy implications for multi-wavelength follow-up studies of FRBs, which I also discuss in this talk.

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A fast radio burst localized at detection to a galactic disk using very long baseline interferometry

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Localizing FRBs is the key to understanding their origins and unlocking their full potential as probes of cosmology. With ~90% of FRBs not known to repeat, building capabilities to solve this problem is of utmost importance. We report here the very first VLBI localization of a non-repeating FRB (FRB 20210603A; Cassanelli, Leung, Sanghavi+23) to a host galaxy using CHIME, and two outrigger testbeds, the Algonquin 10-m telescope (Cassanelli+21) and the TONE interferometer (Sanghavi+23) at Green Bank Observatory. We will describe the method, basis for the CHIME/FRB Outriggers project, proof of our localization, and science implications for FRB 20210603A. Ultimately we demonstrate the viability of a wide bandwidth VLBI method at sub-GHz frequencies which will localize thousands of FRBs to their host galaxy at ~50 mas precision with CHIME/FRB and its outriggers.

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Improving FRB detection with the Kalman Detector

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Detecting Fast Radio Bursts (FRBs) with frequency-dependent intensity remains a challenge as existing search algorithms do not account for the spectral shape, leading to decreased sensitivity. In this talk, I will present a novel detection method called the Kalman detector, which improves the sensitivity of FRB signal detection by incorporating spectral shape information. The Kalman detector is based on an optimal matched filter, marginalizing over all possible intensity functions, weighted by a random walk probability distribution, considering some decorrelation bandwidth. I will present results obtained by applying the Kalman detector to ASKAP-detected FRBs, demonstrating a sensitivity improvement of 0–200% (median improvement of 20%) compared to traditional flux integration. I will discuss its practical applications and potential impact on the search for radio signals with spectral structures.

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The Path to a Next-Generation Galactic Electron Density Model

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Galactic electron density models provide critical inputs to the dispersion measure (DM) and scattering budgets of fast radio bursts (FRBs), in addition to their role in understanding Galactic pulsar populations. The total Galactic electron density distribution includes the Galactic disk, typically modeled using NE2001 or YMW16, and the circumgalactic medium (CGM), for which a wide range of models exist. Uncertainties in these models propagate into FRB constraints on the intergalactic medium, the CGM of intervening galaxies, and FRB hosts. Recently, the detection of a few localized, extragalactic FRBs with total DMs less than the Galactic contributions predicted by a combination of NE2001 or YMW16 and models for the Milky Way halo corroborate the discrepancies found between their predictions for pulsar distances and independently determined distances. These results have strained prior assumptions about the range of DMs for which non-localized bursts may confidently be called extragalactic. Recent updates and expansions to the available sample of pulsar parallaxes have also demonstrated a clear need for the modification of Galactic disk models. This talk will discuss the current state of Galactic density models, their impact on FRB studies, and the work we are currently undertaking to build an improved, next-generation Galactic density model. In addition to an expanded sample of pulsar parallaxes, the new model will leverage high-resolution continuum observations of the Galactic ISM, such as the SDSS V Local Volume Mapper. As in NE2001, the new model will properly account for density fluctuations and scattering observables. Best practices for the current use of Galactic density models will be discussed, including the upcoming release of a native Python implementation of NE2001 and development of an entirely new electron density model.

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Large Scale Structure Cross-Correlations with the First CHIME/FRB Baseband Catalog

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The first CHIME/FRB catalog consisted of hundreds of 492 unique fast radio burst (FRB) sources, and angular cross-correlations of these sources with galaxy catalogs have previously been conducted. Recently, a subset of these bursts with raw voltage (baseband) data have been processed in the first CHIME/FRB baseband catalog. A subset of 135 unique FRB sources have baseband data, with localizations obtained to, on average, < 1' localization precision, as compared to the previous Catalog 1 localization uncertainties of ~10'. These more precise localizations can probe significantly smaller angular scales. We discuss angular cross-correlations of CHIME/FRB sources with galaxy catalogs at these smaller angular scales, as well as how such results may improve with future FRB catalog releases.

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The First Baseband CHIME/FRB Catalog

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The First CHIME/FRB Catalog presented 536 fast radio bursts (FRBs) detected by the Canadian Hydrogen Intensity Mapping Experiment Fast Radio Burst (CHIME/FRB) Project, observed from 2018 July 25 to 2019 July 1. From this sample, we have successfully captured and processed the raw voltage (baseband) data of 140 bursts, including 12 bursts from 7 repeaters previously reported in literature. These bursts comprise the first catalog of FRBs with baseband data made available to the broader FRB community. Baseband data allow for a richer view of FRBs, enabling the study of high-time resolution morphological burst properties and polarization properties. With baseband data from CHIME/FRB, FRBs can also be localized to sub-arcminute precision, thus enabling host galaxy identification for FRBs with low dispersion measure (DM). Having this localization precision for a catalog-size sample of FRBs also means angular cross-correlation studies can statistically probe much smaller angular scales than was previously possible. We present an overview of results from the catalog, including studies of short-timescale morphology, polarization, and brightness measurements. We also briefly highlight other ongoing projects with this baseband catalog data, including work on host galaxy identification and large scale structure cross-correlations.

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Observational links between Magnetars and Fast Radio Bursts

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With exceptionally high magnetic fields, highly variable X-ray emission, and sometimes transient radio emission, magnetars constitute an enigmatic class of isolated neutron stars. The highly dynamic behavior of magnetars in the form of X-ray outbursts and flares, as well as their anomalously high luminosities in some cases, is ascribed to their high magnetic activity and spontaneous field decay. Magnetars also form the basis of a number of theoretical models to explain the origin of fast radio bursts (FRBs). In April 2020, a very strong radio burst from the Galactic magnetar SGR 1935+2154 with a fluence of 1.5 MJy-ms (i.e., only about 30 times less energetic than the weakest FRBs) was observed. While this burst provided support to the above mentioned theoretical models, further observational evidences of links between magnetars and FRBs remain sparse and need more focused efforts. I will present radio observations of magnetars, one of which has been active at radio wavelengths for over four years now, primarily addressing the question: can Galactic magnetars indeed give rise to FRB-like emission?

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Studying the polarimetric properties of FRB 20201124A using the Nançay Radio Telescope

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FRB 20201124A is one of only a few repeating FRBs with measured RM variations. It is a hyperactive source discovered by the CHIME/FRB collaboration. Previous studies show that this FRB had a highly variable RM at some point and then seemed to stabilize over time. It is also one of the few

repeating FRBs to show some degree of circular polarization. We recorded roughly 100 bursts from this FRB during our observations with the Nançay Radio Telescope as part of our FRB monitoring campaign, called ECLAT (Extragalactic Coherent Light from Astrophysical Transients) in early 2022. These measurements were made with a high temporal resolution of 16 microseconds and bandwidth of 512 MHz centered at 1.3 GHz. We calculated the RM of each burst using RM-synthesis and joint QU-fitting. Through long-term monitoring of the source and studying its polarimetric properties, we can add valuable information about changes in the local environment. I will describe the RM variations both within and between these bursts, and compare them with proposed progenitor and emission models.

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Deciphering the Origins of a Nearby Repeating Fast Radio Burst in a Globular Cluster

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Many fast radio burst (FRB) progenitor models predict multiwavelength emission from FRBs, yet no electromagnetic radiation has been detected to date from any extragalactic FRB source, at any wavelength, outside of the radio band. The landmark discovery of an X-ray burst accompanying an FRB-like radio burst from the Galactic magnetar SGR 1935+2154 provided strong evidence that FRB-emitting extragalactic magnetars may also produce X-ray emission at the times of luminous radio bursts, which should be detectable from nearby sources in the local Universe. In this talk, I will present results from a sensitive, broadband simultaneous X-ray and radio observational campaign of the closest known extragalactic repeating FRB source, FRB 20200120E, which resides in a ~10 Gyr-old globular cluster within the M81 galactic system. I will describe new constraints on possible progenitors of FRB 20200120E and compare the results to various classes of X-ray sources and transients, as well as predictions for multiwavelength emission from popular FRB models. I will also discuss the prospects for detecting X-ray emission from nearby FRB sources, going forward, using current and next-generation X-ray telescopes.

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Host Galaxy of the Active Repeating FRB 20190520B

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The properties of a fast radio burst (FRB) host galaxy and its associated stellar populations provide critical information for inferring the progenitor and radiation propagation mechanism of the FRB. We report a detailed analysis of the optical wavelengths of the host galaxy of the active repeating FRB 20190520B. This host galaxy is a low-metallicity, star-forming dwarf galaxy. The ionized gas in the host galaxy is distributed around the locations of the FRB and a persistent radio source (PRS) and is concentrated in the north of the galaxy. Traced by H-alpha emission, the ionized gas can provide a significant contribution to the dispersion measure (DM) of the FRB. Analysis of emission line ratios suggests that the emission features are mainly caused by star formation activities. However, low-mass galaxies that host active galactic nuclei (AGN) are often misclassified as star-forming due to selection bias. Since an AGN can be offset from the optical center of its dwarf host galaxy, and the radio properties of the PRS are consistent with those of an AGN, it is not possible to rule out the scenario that the host galaxy of FRB 20190520B contains an AGN.

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Probing progenitor environments of FRBs using polarimetric properties.

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Even ~15 years after the discovery, the FRB emission mechanism, progenitor environment, and the progenitor remain poorly understood. Additionally, it is unclear what is the relationship between repeating and non-repeating FRB sources. The spectro-polarimetric behaviour of FRBs can potentially play an important role in resolving these questions. For example, the spectral depolarisation of repeating FRBs has led to the conclusion that they reside in a complex, highly magnetised plasma. Similar depolarisation studies with a subsample of ASKAP non-repeating FRBs suggest environments that are likely less magnetised but equally complex. Additionally, circular polarisation observed in FRBs can be a vital tool in understanding their circumburst magnetised medium. The circular polarisation previously observed in some of the repeating FRB sources has been attributed to propagation effects such as generalised Faraday rotation (GFR), where conversion from linear to circular polarisation occurs due to the non-circular modes of transmission in relativistic plasma.

Here we report on the spectro-polarimetric studies of FRBs observed with ASKAP and Parkes radio telescopes and interpret their properties. To understand the relative differences in progenitor environments of repeating and non-repeating FRBs, we extend the depolarisation analysis to a large set of non-repeating FRBs localised by ASKAP. We assess if any non-repeating FRB originates in an extreme environment, and if depolarisation-measure σ_{RM} shows correlations with rotation measure (RM) and pulse broadening time τ_s, as seen in repeating FRBs. We also model the circular polarisation in the first breakthrough listen (BL) detection of repeating FRB 20180301A. We attribute the circular polarisation to GFR. We revise the previously measured RM for the burst, showing that the variations in RM are less extreme than previously thought. We conclude by assessing how depolarisation and circular polarisation of FRBs can be used to understand burst magneto-ionic environments.

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A High-Time Resolution Study of 24 Repeating FRBs with CHIME/FRB

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Recently, the CHIME/FRB collaboration published a sample of 24 repeating FRBs. For ~40 bursts from these 24 repeaters, we captured raw voltage data at a time resolution of 2.56 microseconds with many bursts containing noteworthy structure e.g., a burst which drifts down across the entire 400 MHz CHIME bandwidth and an ultra-wide (~50 ms) burst with no evidence of scattering or substructure. In this work, I will present the results of studying this high-time resolution dataset, first showing particularly interesting bursts and then addressing questions such as: do repeaters show different scattering features than non-repeaters and hence might originate from different environments? In what proportion of repeating FRBs do we see microstructure? Do more active sources show different morphology characteristics e.g., bandwidth, duration, or drift rate? We will also explore whether scattering vs. DM relation amongst these sources, and compare our results with those from the first CHIME/FRB baseband catalog.

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Constraining FRB-like Radio Emission from 28 SGRBs using CHIME/FRB

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Since the commissioning of CHIME/FRB in 2018, 28 short gamma-ray burst (SGRB) objects have been within CHIME/FRB's FOV either before (up to 6 hrs), during, or after (up to 12 hrs) the time of their high-energy emission. Of these, two SGRBs were within the FOV of CHIME/FRB at the time of their high-energy emission. For all of these SGRBs, no FRB candidates were temporally (up to one week) and spatially (within 3 sigma) coincident. Thus, using models of CHIME/FRB's beam response and sensitivity, we determine upper limits on the FRB-like radio emission before, during, and after the high-energy emission for these 28 SGRBs. Using all of our limits, we can constrain the radio to high-energy fluence ratios to be $< 10^{-8}$ for approximately 6 hrs prior to the high-energy emission up to 12 hrs after the high-energy emission. Additionally, at three hours prior to the high-energy emission, we can constrain the radio to high-energy fluence ratio to be $< 10^{-10}$. We use these limits to constrain certain models for FRB-like emission from SGRBs.

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Connecting the Giant Pulses from J1823–3021A in Milky Way Globular Clusters and the M81 Fast Radio Burst

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The progenitors of the Fast Radio Bursts (FRBs) are presently largely unknown, although magnetars are a leading candidate. Magnetars result from core-collapse supernova events in young high-mass stars, so the discovery of a repeating FRB (FRB20200120E) from a globular cluster (GC) associated within the nearby spiral galaxy M81 came as a complete surprise since most GCs are thought to be far too old to still host such young stars. However, GCs host substantial numbers of millisecond pulsars (MSPs), known to emit "Giant Pulses (GPs)", which are remarkably intense bursts of radio emission that can exceed the typical pulse strength by many orders of magnitude. GPs from such millisecond pulsars and the FRBs from the GC in M81 occur on similar microsecond to millisecond timescales. Studying the properties of GC MSPs that emit GPs may give us clues to a connection to the GC FRBs. Here we present our observations of the giant-pulse emitting MSP J1823–3021A in the GC NGC6624, taken in the UHF-band (580-1015 MHz) using the MeerKAT radio telescope in South Africa. These observations were conducted as part of the MeerTIME large science project with a system equivalent flux density (SEFD) of 7 Jy across 400 MHz of bandwidth and a time resolution of ~1 µs. Due to this advantageous setup, and the steep spectral index of the pulsar, we anticipate detecting a significantly higher number of GPs from this MSP than previous studies. With a preliminary investigation on the first 15-min of the observation, we have already detected ~4000 GP candidates with signal-to-noise ratio > 7. For our 1-hour observation, we are thus expecting many more GPs. The baseband nature of our data will enable us to both coherently dedisperse and coherently descatter the GPs, leading to more meaningful comparisons of their properties with those from the FRB.

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Detecting strongly lensed fast radio bursts with upcoming telescopes

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The delay between multiple images of a strongly lensed fast radio burst (sl-FRB) can be used to measure cosmological parameters such as the Hubble constant and the space curvature with high precision, other than obtaining important information on the lens. However, detecting sl-FRBs is challenging because their fraction is low and decreases quickly at low redshifts. Moreover, it requires observing at least two images of an sl-FRB separated by O(10) days. We developed detailed simulations to estimate how many sl-FRBs upcoming radio facilities such as CHORD and DSA-2000 could detect by using different observing strategies. In particular, we consider targeting known lensed galaxies, long-term observations of the North Pole, and following up on FRBs showing signs of microlensing in their signal. Our simulations account for important effects such as wave propagation in the lens galaxy and magnification of point sources distributed within the host galaxy. In this talk, I will review our results on the prospects of detecting and using sl-FRBs in the next few years.

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Dealing with FRBs in the SKA Regional Centres network

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At regime, SKAO is expected to provide the researchers with an annual amount of several hundred PBy of data. The advanced analysis of all those data will take place within a network of so-called SKA Regional Centres (SRCs), which, under the 'Findable, Accessible, Interoperable, and Reusable' (FAIR) principles, will also take the responsibility for curating and archiving both the Observatory Data Products and user-generated Advanced Data Products, as well as for helping the researchers in the estimate of the needed computational effort at the proposal stage.

This contribution describes the status and the perspectives of this international network, which is now at the stage of drawing the basic principles upon which several stages of implementations will follow, roughly in pace with the various phases of the construction of the telescope. In particular, the now predicted capability of the SRC network will be around 30-40 Pflops, which may leave room for unprecedented opportunities for post-processing and data analysis of time domain and FRB data.

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frb-voe: A Standardized Mode of FRB Communications Through Virtual Observatory Events

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In the past decade, efforts from many observatories and collaborations has led to significant constraints on FRB progenitor models, however, the nature of FRB progenitor(s) remains a mystery. With observations like that of the galactic magnetar SGR 1935+2154, we have shown that localizations and multi-wavelength follow-up are promising ways to determine FRB progenitors. However, since no single observatory can excel in detecting, localizing and observing FRBs across many wavelengths, cooperation and communication between observatories is crucial. Hence, we introduce frb-voe, a real-time alert service that provides standardized infrastructure through which FRB observatories can communicate. A virtual observatory event (VOE) is a machine-readable alert that describes an astrophysical transient event. In other transient fields of astronomy, Virtual Observatory Events (VOEs) have been largely successful in providing an effective mode of communication, for example, dozens of Gamma Ray Burst follow-ups achieved through the Gamma Ray Coordinates Network. We also describe a specific use-case of frb-voe at the Canadian Hydrogen Intensity Mapping Experiment (CHIME). Over the past 2 years, this service demonstrates the power of frb-voe, as CHIME is an excellent FRB detector but cannot provide the tightest constraints on localization nor on multi-wavelength observations. However, through frb-voe, other observatories such as Swift GUANO have used CHIME/FRB VOEvents to perform follow-up observations of FRBs.

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Probing FRB localisation accuracy and FRB detection limitations when using EVN VLBI backends

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Despite a decade of intense research, the physical origin of fast radio bursts (FRBs) is still unknown. One key-element required to crack the FRB-puzzle are the physical conditions in the surroundings of FRBs. E.g., do FRBs reside in star forming regions or not? If found in a globular cluster, how close to the cluster core are they? Besides high-resolution optical data, a high-precision localisation of the source in the radio band is essential to answer such questions. Only very long baseline interferomtry can provide a spatial resolution matching that of, e.g., Hubble and JWST. However, the short duration of FRBs and the limited number of bursts typically detected in one observing run introduce systematic uncertainties in the localisation. Such systematics need to be well understood to draw robust conclusions about the origin of FRBs. Moreover, particular FRBs have been seen to emit bursts over a wide range in energy (over up to 6 order of magnitude). At the high-energy end, such bursts introduce artifacts in the 2bit recording system that are used at most VLBI stations. In this talk we will discuss experiments with synthetic FRB-signals that were used to probe the possible localisation accuracy given different VLBI-array setups, calibration errors, and burst properties. We also tested our overall FRB detection-pipeline for extrememly bright (S/N > 100) bursts, finding that a burst similar to the one detected by CHIME/FRB and STARE2 from SGR1932+2154 might have gone undetected with our VLBI-backend.

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Radio Monitoring Observations of the Nearby Repeating FRB 20181030A

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FRB 20181030A is a nearby repeating fast radio burst (FRB), discovered by the Canadian Hydrogen Intensity Mapping Experiment's (CHIME) FRB Instrument in 2018 October. In the two years after the initial detection, 8 more bursts were detected using CHIME/FRB. The most likely host galaxy of FRB 20181030A is a star-forming spiral galaxy (NGC 3252), which resides at a distance of ~20 Mpc, likely making it the second closest repeating FRB source. FRB 20181030A is thus an excellent candidate for multiwavelength follow-up since it is likely located nearby. In this talk, I will present results from daily radio monitoring observations of FRB 20181030A using the CHIME/Pulsar instrument, outfitted on the CHIME radio telescope. The CHIME/Pulsar instrument is able to record coherently dedispersed data at high time resolution using its tracking beam capabilities. Radio bursts, with narrow microsecond-wide components, have been detected in baseband data containing bursts from FRB 20181030A, suggesting that the source may produce coherent radio emission on timescales well below the ~1 ms time resolution of the CHIME/FRB instrument. I will present results characterizing the source's recent emission behavior, activity level, and repetition rate. I will also describe the pipeline that is being used to perform a deep search for radio bursts and measure their properties.

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Investigating nearby fast radio bursts with Bustling Universe Radio Survey Telescope in Taiwan

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The growing number of discovered fast radio bursts (FRBs) highlights their increasing significance across various astrophysical domains. However, the lack of nearby FRB detections and the challenges in precise localization hinder a comprehensive understanding of FRB physics and its implications. Therefore, the Bustling Universe Radio Survey Telescope in Taiwan (BURSTT) aims to capture and precisely localize bright, proximate FRBs. With its extensive sky coverage and extended observation periods, BURSTT-256 (phase I) anticipates detecting approximately 100 FRBs with a fluence exceeding 100 Jy ms per year. Along with the outrigger stations in Taiwan, Hawaii, India, and other regions, BURSTT will achieve pinpoint localizations at subarcsecond scales. In this presentation, we will introduce the BURSTT initiative and provide an overview of its current progress.

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Low frequency uGMRT followup observations of persistent radio sources associated with repeating FRBs 20121102 and 20190520B

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Multi-frequency and multi-band observations of FRB neighbourhoods can reveal interesting physics happening in the local environments and provide insight into the nature of the FRB progenitors. FRB 20121102, the first repeating FRB discovered has been extensively studied. The localisation of this source in 2017 was followed by the discovery of a relatively flat spectrum persistent radio source in the 400\,MHz to 6\,GHz range of frequencies. Magnetars are considered as the ideal sources for FRBs owing to the discovery of an FRB like burst from the galactic magnetar. Models involving magnetar wind nebula and supernova remnants predict a decrease in flux density with time and a steepening spectral power law index. I will present results of our recent follow-up observations of this persistent source using upgraded Giant Metrewave Radio Telescope (uGMRT) in three frequency bands from 300\,MHz to 1.5\,GHz. FRB 20190520 is another repeater with an associated persistent radio source. The spectrum of this source resembles the FRB 20121102 counterpart in the GHz frequencies. However, there are no low-frequency (<1 GHz) observations of the FRB 20190520 persistent radio source. Lower frequency observations may help to more strongly constrain the progenitor of the FRB as a break in the spectrum at lower frequencies may indicate a relation to a super luminous supernova. I will discuss our lower frequency uGMRT observations of the FRB190520 counterpart and comment on the temporal evolution of the radio source since its last observation in 2020.