# SPINS-UK 2022
# List of Abstracts

## Gravitation

### Continuous gravitational waves from spinning neutron stars

**Hannah Middleton – Birmingham**

Gravitational waves (GWs) come in many shapes and sizes. So far transient signals from merging compact objects have been observed, but ground-based GW observatories are also searching for other types of signal too. One of these, as yet undetected signals, are continuous GWs: long lasting quasi-monochromatic signals expected from spinning neutron stars. These signals should be present in detector data all the time, the challenge is to find them! A Hidden Markov Model is a continuous GW search method which allows a signal with slowly wandering frequency to be tracked over the course of an entire observing run of ground-based GW detectors [Suvorova+2017] and one of the prime targets for these searches is neutron stars in low mass X-ray binaries. Besides being an active area of research in the hunt for continuous GWs with LIGO-Virgo-KAGRA [e.g. LVK+2022, Middleton+2020], these techniques can also be demonstrated with table-top equipment providing opportunities for cross-disciplinary learning for students in physics and electrical engineering [Gardner+2022].

### The complex g-mode spectrum of reacting neutron stars

**Rhys Counsell – Southampton**

In this talk I discuss the impact of nuclear reactions and stratification on the spectrum of gravity g-modes of a mature neutron star using the BSK21 equation of state. The framework for the analysis will be presented along with numerical results. The reactions imply the damping of oscillation frequencies and suppression of higher order overtones in contrast with the classical analysis of an infinite spectrum. I will also discuss the behaviour of the spectrum in the transition period between fast and slow reaction regimes.

## Gravitational waves from accretion-driven thermal mountains in magnetised neutron stars

**Thomas Hutchins – Southampton**

Rapidly rotating neutron stars in low-mass X-ray binary (LMXB) systems may have their spin frequencies limited by the emission of gravitational waves. It has been suggested that temperature asymmetries in the crusts of accreting neutron stars may lead to a misaligned quadrupole moment, producing gravitational wave emission at twice the spin frequency. The origin of such temperature gradients are, however, uncertain. We suggest one mechanism to generate the required temperature asymmetries is to assume the neutron star is threaded by an internal magnetic field, thus rendering the thermal conductivity anisotropic. We present our findings that for moderately-high accreting neutron stars ($\dot{M} \geq 10^{-9} M_{\odot}\,\mathrm{yr}^{-1}$), the internal crustal magnetic field strengths required to generate temperature asymmetries capable of producing significant gravitational wave emission can be much smaller than previous estimates.

# Pulsar timing

## Pulsar timing noise, oscillations, and gravitational waves

**Ian Jones – Southampton**

Despite being excellent clocks, radio pulsars display a low level of timing irregularity, colloquially termed "timing noise". The physical origin of timing noise is not yet understood. We present a model of timing noise based on the excitation of many small f-mode oscillations of the pulsar. We present results on how these oscillations affect the rotational evolution of the star. We also comment on the potential detectability of the corresponding gravitational wave signals. Our results form the basis for a novel multi-messenger study of pulsars. [Based on Yim and Jones arXiv:2109.05076].

## Pulsar timing noise from "internal" and "external" torque fluctuations

**Marco Antonelli – LPC Caen**

I will present the minimal stochastic model that can be used to describe the spin-down of a neutron star by accounting for fluctuations in the internal and external torques of a rotating neutron star. The power spectral density and timing noise strength can be obtained analytically, and compared with known results from pulsar timing observational campaigns. Flat (white) regions of the power spectral density can be interpreted as a signature of the presence of internal superfluid components. More generally, this minimal framework offers a simple theoretical guideline to interpret some observed features of timing noise in single pulsars and across pulsar population. Its limitations will also be discussed. Based on https://arxiv.org/abs/2206.10416 by M. Antonelli, A. Basu and B. Haskell.

## Long-term emission and rotational variability in radio pulsars

**Benjamin Shaw – Manchester**

With the ever-increasing sensitivity and timing baselines of modern radio telescopes, a growing number of pulsars are being shown to exhibit transitions in their rotational and radio emission properties. In many of these cases, the two are correlated with pulsars assuming a unique spin-down rate for each of their specific emission states. I will describe work in which we revisited 17 radio pulsars previously shown to exhibit spin-down rate variations. Using a Gaussian process regression method to model the timing residuals and the evolution of the profile shape, we confirm the transitions already observed and reveal new transitions in 8 years of extended monitoring with greater time resolution and enhanced observing bandwidth. We confirm that 7 of these sources show emission-correlated spin-down transitions and we characterise this correlation for one additional pulsar, PSR B1642−03. Linking spin-down variations to changes in the global magnetospheric charge density we speculate that spin-down transitions associated with large changes to plasma density may be exhibiting detectable profile changes with improved data quality, in cases where they have not previously been observed.

## The Jodrell Bank glitch catalogue

**Avishek Basu – Manchester**

Pulsar glitches are rapid spin-up events that occur in the rotation of neutron stars, providing a valuable probe into the physics of the interiors of these objects. Long-term monitoring of a large number of pulsars facilitates the detection of glitches and the robust measurements of their parameters. The Jodrell Bank pulsar timing programme regularly monitors more than 800 radio pulsars and has accrued, in some cases, over 50 years of timing history on individual objects. In this talk, I will discuss 106 new glitches in 70 radio pulsars as observed up to the end of 2018. For 70% of these pulsars, the event we report is its only known glitch. For each new glitch we provide measurements of its epoch, amplitude and any detected changes to the spin-down rate of the star. Combining these new glitches with those listed in the Jodrell Bank glitch catalogue we analyse a total sample of 543 glitches in 178 pulsars. We model the distribution of glitch amplitudes and spin-down rate changes using a mixture of two Gaussian components. We corroborate the known dependence of glitch rate and activity on pulsar spin-down rates and characteristic ages, and show that younger pulsars tend to exhibit larger glitches. Our results are qualitatively consistent with the superfluid vortex unpinning models of pulsar glitches.

## The European Pulsar Timing Array – Data Release 2.0

**Golam Shaifullah – Milan**

Pulsar timing arrays (PTAs) are inching closer to the detection of the stochastic gravitational wave background (GWB), most likely produced through the inspiral of nearly circularised SMBHBs. In the coming months the European Pulsar Timing Array (EPTA) will be releasing its latest dataset, adding approximately ten years of high precision pulsar timing data to bring the total timespan up to almost 25 years. This new dataset contains almost twice the previous data volume, and is leading to significantly increased (pulsar timing) precision. A small part of this new dataset has already been used to place the EPTA's current limit on the amplitude of the stochastic GWB as well as showing the presence of a common but spatially uncorrelated red noise process, and the full dataset will be used to significantly improve the current results at both, lower and higher frequencies, as well as investigating a number of other PTA scientific objectives. I will present the current state of the dataset, our release plans and early science insights.

## A search for planetary companions around 800 pulsars from the Jodrell Bank pulsar timing programme

**Iuliana Niţu – Manchester**

The first ever exoplanets were discovered exactly 30 years ago around PSR B1257+12, which is now known to host at least three planets similar in masses and orbits to some of the rocky planets in our solar system. Only a few other planetary-mass companions have since been found around pulsars, and we have yet to understand how a rocky planetary system would form and survive in such extreme conditions.

Pulsar timing offers exceptional precision in detecting the influence of companions. In this talk, I will present the results of the largest search for planets orbiting pulsars to date. This work was achieved using observations of 800 pulsars over the last 50 years at the Jodrell Bank Observatory. Using a Bayesian method, we searched for orbital periods between 20 days and 17 years, and companion masses between 0.0001 and 100 Earth masses. We find that fewer than 0.5% of pulsars could host terrestrial planets as large as those orbiting PSR B1257+12, confirming that it is a very rare system. I will also discuss which of our pulsar systems are the likeliest candidates for hosting planets, and the implications of the detection limits that can be inferred for the 800 pulsars.

## Measuring glitch recoveries

**Yang Liu – Manchester**

TBD

# Binaries/High-energy sources

## Optical surveys for Spider pulsars near $\gamma$-ray point sources

**Adipol Phosrisom – Manchester**

Spiders are binary systems containing a millisecond pulsar (MSP) and a low-mass companion star that is being ablated by the intense pulsar wind. While MSPs are most commonly identified by their radio pulsations, this ablation can completely eclipse their radio emission for large fractions of their orbital periods, making them easy to miss in typical all-sky surveys. However, MSPs are prolific gamma-ray emitters, and so one way to discover new Spider systems is by targeting unidentified gamma-ray sources. New Spider candidates near the gamma-ray sources are detected by their periodic signals and sinusoidal light curves. Since April 2022, four objects were identified as Spider candidates in an ongoing survey project using ULTRACAM at La Silla.

## "Pauses" in the rises of Type−I X-ray bursts

**Arianna Albayati – Southampton**

Thermonuclear type-I X-ray bursts are sudden increases in X-ray emission from neutron star LMXBs over timescales of seconds, caused by runaway thermonuclear burning of material accreted onto the neutron star's surface. Since its launch, NICER has provided many rich datasets of X-ray bursts. Thanks to NICER's superb timing resolution combined with a large effective area we are able to study new phenomena. Historically, the rises of Type-I X-ray bursts have generally been described as relatively fast and smooth. Recent studies on bursts from SAX J1808.4–3658 and MAXI J1807+132 have revealed "pauses" of 0.7s and 1.6s respectively in the rises of bursts. The X-ray bursts from these sources differ greatly in composition and peak burst luminosity, suggesting that the origin of these pauses is independent of many LMXB properties. In this talk I will outline our investigation into related phenomena and discuss possible causes for these new discoveries.

## The multiwavelength view of PSR B1055−52

**Bettina Posselt – Oxford**

PSR B1055−52 is a nearby, middle-aged, radio, X-ray, and Gamma-ray pulsar. The neutron star is also seen in the optical-UV spectral range where only few pulsars are detected. A recent Hubble observation allowed us to measure the Near-Infrared flux of this object. Based on these measurements we constrain the pulsar's spectral shape in the NIR-UV and interpret it in connection with the high-energy spectrum. A comparison of previous X-ray observations, Chandra (2012) and XMM-Newton (2000), showed a surprisingly large ($> 30\%$) flux difference. Our new XMM-Newton observations allowed us to probe the stability of the X-ray spectrum and flux which I will also discuss.

## A light redback companion of PSR J1622−0315 and irradiation power in spider systems

**Yee Xuan Yap – MSSL/UCL/National Tsing Hua University**

We present the optical light curves of the millisecond pulsar binary system PSR J1622−0315 obtained by the Lulin 1m telescope in Taiwan and the Lijiang 2.4m telescope in China. Our observation showed that the companion of the pulsar, which is of V∼19 mag, has an ellipsoidal-distortion induced orbital variations. The best-fit model, from the binary code PHOEBE 2.3, gave a companion mass of 0.128±0.006 solar mass. This places PSR J1622−0315 as a spider system. We examine the light curve of PSR J1622−0315 together with the other spider pulsar binaries, by comparing their scalings between the irradiation luminosity of the companion, the X-ray luminosity of the binary, and the spin-down luminosity derived for the pulsar. We found that transitional millisecond pulsars PSR J1023+0038 and PSR J1227−4853 have the highest irradiation luminosity among redback pulsars, and concluded that the pulsar heating of the PSR J1622−0315 companion is not significant.

## Constraining mass of neutron star in ultra-compact binary with multi-messenger observations

**Kaye Jiale Li – MSSL/UCL**

Neutron stars are crucial for our understanding of the densest matter in the Universe. Different internal structures and compositions determine the maximum possible mass achievable, before the neutron stars collapse under their own gravity. Ultra-compact millisecond pulsar binaries with orbital period 1 hour are found to hold massive neutron stars. To probe the mass of neutron stars in such binaries, we proposed a new method by combining multi-messenger observations. We consider the mass function from optical light curve observation and combine the parameter estimation from gravitational wave observation using space-borne detector LISA. We show that gravitational wave provide complimentary information to resolve the mass-inclination angle degeneracy in the mass function, greatly improving the constrains of the parameters. We show that even for marginally detected systems with gravitational wave SNR ∼5, the neutron stars' masses can be constrained to be within 10%.

# Equation of state/Neutron star structure

## Where Is The Love? The dynamical tides of rotating neutron stars

**Fabian Gittins – Southampton**

Ground-based gravitational-wave instruments have witnessed several binary coalescences that comprise at least one neutron star. In these binaries, tidal interactions deform the star and imprint finite-size corrections on the associated gravitational waveform. These finite-size effects depend on the interior stellar composition and present a promising opportunity to constrain the elusive nuclear-matter equation of state. With current-generation detectors improving in sensitivity and future observatories planned, it proves timely to consider the weaker dynamical effects on the gravitational-wave signal. We study the dynamical tides of spinning stars. Stars possess a spectrum of normal vibrational modes, which become excited by the presence of an exterior gravitational field. We calculate the stellar response to a tidal field and present an expression for the effective Love numbers in terms of the natural modes. We find that rotation introduces a coupling between the prograde and retrograde modes that was not present in the non-rotating case. Considering the static tide, we show that rotation modifies the deformability at second order.

## Nuclear physics constraints from multimessenger resonant shattering flares

**David Tsang – Bath**

Neutron stars are an ideal laboratory for studying the properties of dense nuclear matter, where many-body interactions signifcantly complicate the physics. These interactions are often described by the binding energy of symmetric nuclear matter (SMN), and the symmetry energy - the difference between SMN and pure neutron matter. I will discuss the current constraints on the symmetry energy parameters from terrestrial collider experiments and compare these to what can be obtained from current and future neutron star observations. I will focus particularly on Resonant Shattering Flares, which can provide symmetry energy constraints comparable to collider experiments with a single multimessenger detection.

## Distinguishing dynamical tides in inspiralling binary neutron stars

**Natalie Williams – Birmingham**

Tidal measurements from binary neutron star inspirals give the opportunity to investigate the currently unknown neutron star equation of state and hadronic to quark phase transitions. Leading order adiabatic tides have been constrained in

GW170817, and with the introduction of higher sensitivity third generation (3G) gravitational-wave detectors, higher order dynamical tides may also come into view. Dynamical tides are characterised by the neutron star's fundamental (f-) mode frequency, here we investigate the prospects for distinguishing dynamical tides in 3G observations and also give an example for measuring the f-mode frequency for a GW170817-like source. We find that in a simulated population of 10000 binary neutron star mergers we can expect to measure at least O(50) signals with dynamical tides, and using a GW170817-like event we measure the f-mode frequency to within a few hundred Hz.

## Energetics of the Elastic Mountain on a Neutron star under the starquake model

**Yashaswi Gangwar – Southampton**

Non-axisymmetric deformation of a Neutron star when supported by the elastic nature of the crust gives rise to an elastic mountain. In the past, few attempts were made to study the formation of the elastic mountain under the starquake model, but the associated energetics of the process is still not very well understood. We aim to develop a better understanding and improve on recent studies. We tried to compute the maximum ellipticity possible for a Neutron star by performing the complete energy analysis. We also computed the perturbed gravitational potential energy and strain energy of the Neutron star for $l = 2$ $m = 2$ spherical harmonics. Based on our quantitative analysis, we found that a Neutron star cannot acquire the maximum ellipticity as mentioned in the recent studies and is much smaller than the value which was previously thought to be.

## Resonant shattering flares as low density probes of nuclear symmetry energy

**Duncan Neill – Bath**

The nuclear symmetry energy is an important property of hadronic matter, as it describes the change in energy as the proton fraction is changed. While terrestrial experiments can be used to measure it and its dependence on baryon density, the extreme density and isospin asymmetry of matter within neutron stars make them ideal places to study nuclear symmetry energy. Probing the composition and structure of matter within NSs is therefore of great interest to nuclear physics. In our work, we consider resonant shattering flares. These short flares of gamma-rays are produced by resonant excitation of a neutron star's asteroseismic modes and the tidal field of its binary partner shortly before binary merger. A gravitational wave signal detected coincident to such a flare would inform us of the eigenfrequency of the mode which was resonantly excited. This frequency is strongly dependant on the matter in the NS crust, allowing for constraints to be placed on this matter and also on the symmetry energy on which it depends. Unlike other probes of neutron star structure and equation of state, these flares have little dependence on the star's core. This makes them more reliable for studying hadronic matter properties such as symmetry energy, as the possible presence of non-hadronic phases of matter in the core will have little impact on the results.

## Inferring the dense nuclear matter equation of state with neutron star tides

**Pantelis Pnigouras – Alicante**

During the late stages of a neutron star binary inspiral finite-size effects come into play, with the tidal deformability of the supranuclear density matter leaving an imprint on the gravitational-wave signal. As demonstrated in the case of GW170817—the first direct detection of gravitational waves from a neutron star binary—this can lead to strong constraints on the neutron star equation of state. As detectors become more sensitive, effects which may have a smaller influence on the neutron star tidal deformability need to be taken into consideration. Dynamical effects, such as oscillation mode resonances triggered by the orbital motion, have been shown to contribute to the tidal deformability, especially close to the neutron star coalesence, where current detectors are most sensitive. We calculate the contribution of the various stellar oscillation modes to the tidal deformability and demonstrate the (anticipated) dominance of the fundamental mode. We show what the impact of the matter composition is on the tidal deformability, as well as the changes induced by more realistic additions to the problem, e.g. the presence of an elastic crust and superfluidity. Finally, based on this formulation, we develop a simple phenomenological model describing the effective tidal deformability of neutron stars and show that it provides a surprisingly accurate representation of the dynamical tide close to merger.

# Interstellar medium

## Mapping the local interstellar medium with pulsar scintillation

**James McKee – Hull**

It has become increasingly clear that most scintillation is caused by scattering from discrete thin screens in almost all pulsars, many of which are known to persist for decades. This is surprising, as the lines of sight to most pulsars are not coincident with any known plasma structures, and the simplest explanation of spontaneous screen creation, spherical plasma 'blobs', can only produce screens that persist over approximately year-long time scales. Therefore, the origin and nature of these scattering screens is mysterious, despite being a ubiquitous feature of the galaxy. Scintillometry of pulsars has proven to be a sensitive probe for detecting the presence of scattering screens and measuring their astrometric properties. When modelling scintillation variations in pulsars over the course of the Earth's orbit, scintillometry has been demonstrated to be capable of sub-parsec screen localisation, in the best cases. In this talk, I will describe the new methods and recent results that are beginning to shed light on the organisation of the local interstellar medium structure. In particular, I will present the results of an extremely sensitive monitoring campaign of nearby pulsars undertaken with the FAST telescope over the course of the year, with the goal of mapping the Local Bubble.

## Simulating pulsar scattering using ray-tracing

**Joe Butler – Lancaster**

The interstellar medium (ISM) contains structures which can scatter the radio emission beam from a pulsar. The shape of the periodically-observed pulse (the flux over time) can therefore be distorted, due to delayed arrival times of flux taking longer paths. This distortion is quantified by a broadening function. Although this provides information about the ISM, it can also hide features of the intrinsic pulse shape, so exploring the relationship between ISM structures and broadening functions is crucial to understanding pulsar observations.

These structures are well-approximated by thin scattering screens, and analytical solutions of the broadening function do exist for simple cases. However, these solutions become increasingly difficult for more complicated setups. Therefore, a ray-tracing simulation (SIMPLES: SIMulating PuLsar Emission Scattering) was created as a general tool to explore these scenarios.

In this talk, I will give an overview of pulsar scattering and the basic functionality of the simulation. I will then present the results of an investigation into two-screen setups, detailing how the resultant broadening function compares to a single-screen setup, and then extending the analysis to include anisotropic screens (those with preferred scattering directions) at varying relative orientations. Finally, I will present evidence supporting the hypothesis that multiple anisotropic screens could produce an isotropic resultant broadening function (Oswald et. al. 2021).

# Pulsar emission

## Numerical simulations of ambipolar diffusion in neutron stars

**Andrei Igoshev – Leeds**

We numerically model evolution of magnetic fields inside a neutron star under the influence of ambipolar diffusion in the weak-coupling mode in the one-fluid MHD approximation. Our simulations are three-dimensional and performed in spherical coordinates. Our model covers the neutron star core and includes crust where the magnetic field decay is due to Ohmic decay. We discover an instability of poloidal magnetic field under the influence of ambipolar diffusion. This instability develops in the neutron star core and grows on a timescale of 0.2 dimensionless times, reaching saturation by 2 dimensionless times. The instability leads to formation of azimuthal magnetic field with azimuthal wavenumber m=14 (at the moment of saturation) which keeps merging and reaches m=4 by 16 dimensionless times. Over the course of our simulations (16 dimensionless times) the surface dipolar magnetic field decays, reaching 20 percent of its original value and keeps decaying. The decay timescale for the total magnetic energy is six dimensionless times. The ambipolar diffusion induces electric currents in the crust where these currents dissipate efficiently. Strong electric currents in the crust lead to heating, which could correspond to luminosities of 1e29 erg/s during hundreds of Myrs for an initial magnetic field of 1e14 G. Ambipolar diffusion leads to formation of small-scale magnetic fields at the neutron star surface.

## A broadband radio study of PSR J0250+5854: the 23 second radio pulsar

**Patrick Weltevrede – Manchester**

We present radio observations of radio pulsar PSR J0250+5854. With a 23.5 s period, it is close, or even beyond, the P-Pdot diagram region thought to be occupied by active pulsars. The simultaneous observations with FAST, the Chilbolton and Effelsberg LOFAR international stations, and NenuFAR represent a five-fold increase in the spectral coverage of this object, with the detections at 1250 MHz (FAST) and 57 MHz (NenuFAR) being the highest- and lowest-frequency published respectively to date. In conjunction with observations of this pulsar with the GBT and the LOFAR Core, we show that the intrinsic profile width increases drastically towards higher frequencies, contrary to the predictions of conventional radius-to-frequency mapping. The results for PSR J0250+5854 and other slowly spinning rotation-powered pulsars are contrasted with the radio-detected magnetars. We conclude that magnetars have intrinsically wider radio beams than the slow rotation-powered pulsars, and that consequently the latter's lower beaming fraction is what makes objects such as PSR J0250+5854 so scarce.

## Radio pulsar polarization: a broad-band view

### Lucy Oswald – Oxford

For the past half-century, pulsars have been used to push the boundaries of our understanding of the Universe, yet our knowledge of pulsar radio emission is still limited by many unanswered questions. Understanding radio emission processes in the pulsar magnetosphere will enable us to constrain not only pulsar geometries but also the links between radio emission from pulsars, magnetars and FRBs. Polarimetry provides important information about pulsar emission geometry and magnetospheric processes, but the pulsar population exhibits considerable variety in its polarization behaviour that is not well captured by the canonical description of pulsar radio emission. In recent years however, new and upgraded telescopes have given us a broad-band phase- and frequency-resolved perspective of pulsar radio polarization.

In this talk I will present results from a broad-band survey of 271 radio pulsars made with the Parkes Ultra-Wideband receiver. I will discuss the origins of the polarization features observed, focusing particularly on circular polarization, and explain how they can be captured in a simple three-parameter "partially coherent" model. This work updates our picture of radio polarization in the pulsar population, demonstrating the importance of modern phase-resolved and frequency-resolved polarimetry for understanding neutron stars.

## The sub-pulse modulation of 1198 radio pulsars

### Xiaoxi Song – Manchester

I will present the results of a big survey to study the subpulse modulation properties of 1198 pulsars using the Thousand-Pulsar-Array programme on MeerKAT. This study exploits the great sensitivity of MeerKAT. We used a semi-automated pipeline to analyse the more than 1.6 million pulses in a systematic way. We find that 35% of the analysed pulsars show drifting subpulses — implying that 60% of the overall population of pulsars to exhibit drifting subpulses if even higher quality data would be available. This large study reveals the evolution of drifting subpulses across the pulsar population in unprecedented detail. In particular, it is found that the modulation period P3 evolves non-monotonically. The smallest P3, corresponding to the Nyquist period of 2 pulse periods, are found at a characteristic age $\sim 10^{7.5}$ yr. This evolution can be reproduced if young pulsars possess aliased fast intrinsic modulation, which gradually and monotonically decreases, ultimately achieving a slow unaliased subpulse modulation pattern. This explains that the subpulse modulation patterns of young pulsars are more erratic. Modelling these results as subbeams rotating about the magnetic axis, their circulation must slow down as the pulsar evolves. This is the opposite to what is expected if circulation is driven by an ExB drift as suggested by the rotating carousel model. This can be resolved if the observed P3 periodicity is due to a beat between an ExB system and the pulsar period.

## Investigating pulse profile variations in 2D

**Renée Spiewak – Manchester**

Changes in the $\dot{\nu}$ have been observed in many pulsars, as have changes in the observed average profile. Lyne et al. (2010) made the first discovery of 6 pulsars for which these changes in $\dot{\nu}$ and shape are correlated in time. Other studies in the past decade increased that number to $\sim 15$, with the results for some pulsars differing between studies, possibly due to differing methods. In this talk, I will present a project which will increase the sample of pulsars examined for $\dot{\nu}$-shape correlations and will utilise new methods to quantify the shape changes.

# Searches, surveys and new-generation facilities

## Pulsar observations with eMerlin

**Tom Scragg – Manchester/Lancaster**

TBD

## Searching for pulsars in the Small Magellanic Cloud with MeerKAT

**Emma Carli – Manchester**

TRAPUM (TRAnsients and PUlsars with MeerKAT, Stappers  Kramer 2016) is a Large Survey Project of the MeerKAT telescope, a 64-dish radio interferometer and precursor to the Square Kilometer Array. The TRAPUM collaboration is conducting a MeerKAT survey of the Small Magellanic Cloud (SMC), a nearby dwarf galaxy, to search for rare new extragalactic radio pulsars. 7 new pulsars were discovered so far, doubling the known population of pulsars in the SMC, and increasing the total extragalactic population by 25%. 3 out of the 7 pulsars discovered are young, including one in a PWN and a Vela-like glitcher. Our discoveries have the potential to reveal valuable information on many fields of science, by effectively probing the effects of another galaxy's properties onto a neutron star population. In this talk, I present our survey, our novel observing and processing methods, and our discoveries.

## Pulsars in the globular clusters M62 and NGC 6440

**Laila Vleeschower Calas – Manchester**

A new phase of pulsars discovered in globular clusters has started thanks primarily to the FAST and MeerKAT telescopes. Using the later, we have conducted searches for new pulsars in globular clusters (GCs), which are known to be ideal places for the formation of millisecond pulsars (MSPs) due to their high stellar densities in their cores ($\sim 10^{5-6}$ $M_\odot$ pc$^{-3}$) inducing dynamical interactions between stars. In this talk I will focus on the most recent discoveries in M62, a cluster with only pulsar binaries known. I will also present the two most recent discoveries in NGC 6440, one being isolated and the other being a Black Widow with one of the less massive companions known so far ($M_c > 0.006$ $M_\odot$). It joins the other binary pulsars discovered so far in this cluster that all have low companion masses ($M_c < 0.30$ $M_\odot$). We show the outstanding capabilities of MeerKAT for discovering new pulsars in globular clusters.

## Searching for pulsars and fast transients in supernova remnants, pulsar wind nebulae and unidentified TeV sources with MeerKAT

**James Turner – Manchester**

Supernova remnants and pulsar wind nebulae are ideal sources to hunt for young and energetic pulsars. Targeted pulsar searches of such sources have often been limited due to the difficult balance between efficient telescope use and achieving worthwhile sensitivity. However, with the highly adept MeerKAT 64-dish radio interferometer, deep searches of many galactic remnants and wind nebulae are underway as part of the TRAPUM (TRAnsients and PUlsars with MeerKAT) Large Survey Project. Ongoing observations have so far yielded the discovery of a new young pulsar within the candidate composite remnant G22.0450.028. A chance discovery of an as yet unlocalised pulsar with extreme pulse-to-pulse variability has also been made. Our aim of expanding the population of young radio pulsars finds purpose in helping to constrain the galactic neutron star birthrate, early-age spin evolution and also in improving our understanding of the energy budgets between pulsars and their wind nebulae.

## Time-domain capabilities of the SKA telescopes

**Lina Levin Preston – Manchester**

The construction of the SKA telescopes is now underway. Once completed, these telescopes will undoubtedly become amazing instruments for pulsar and fast transient science. The full-scale SKA will be sensitive enough to detect all pulsars within the Galaxy that are beaming towards the Earth, but already the first phase will be able to detect a significant fraction of the pulsar population. The many simultaneous tied-array beams combined with real-time single pulse detection will ensure instant localisation of any fast transient and enable rapid multi-wavelength follow-up. I will present the time-domain capabilities of the SKA telescopes and provide some predictions of the future discoveries from this exceptional observatory.

## Long and ultra long period pulsars

**Ben Stappers – Manchester**

The discovery of a number of radio emitting neutron stars with periods in excess of 10s in the last few years is changing our understanding of the neutron star population. It also presents interesting potential links to other neutron star classes such as Magnetars and perhaps FRBs. I'll present recent discoveries from MeerTRAP at MeerKAT and discuss the growing population as a whole.

## Search for ultra-long period pulsars with LOFAR

**Kaustubh Rajwade – ASTRON**

Time-domain surveys for pulsars and fast transients continue to discover surprising sources that have shaped our understanding of neutron stars and fast radio bursts (FRBs). Recent discoveries of periodic sources with long rotational periods (P > 10 sec) demonstrate that there is a previously hidden population of such sources lurking in our Galaxy in large numbers. These sources are of great interest due to their implications for the radio emission mechanism in neutron stars and their potential links to the mysterious FRBs. Image-plane search techniques are crucial in detecting these sources; LOFAR, with its excellent sensitivity, wide field-of-view and proven ability to find steep spectrum sources, is the right instrument for the job. I will present the LOFAR image-domain pipeline for detecting long-period pulsars. I will discuss the tools and techniques that have been developed in order to perform this search effectively and efficiently. I will present the results of testing this pipeline on archival data from the LOFAR-discovered 23.5-second pulsar, and the relevance of these techniques in the context of upcoming interferometric facilities like the SKA.