# Connecting the dots: From ultra-long period neutron stars to fast radio bursts

Since the discovery of neutron stars over five decades over, more than 3000 of these enigmatic objects have been discovered. Neutron stars come in a variety of flavours ranging from millisecond pulsars to the more recently discovered Ultra-Long Period Neutron Stars (ULPNSs). The discovery of the latter, emitting unusual radio signals is rewriting our understanding of these unique star systems. Recently, a couple of such long period neutron stars have been found to reside in the neutron star graveyard and yet produce radio emission. The most recent ULPNS, PSR J0901-4046 discovered with the MeerKAT telescope in South Africa lives in the neutron star graveyard and completes one rotation every 76 seconds. It exhibits highly unusual, and chaotic pulse shapes quite unlike anything seen in known neutron stars, with certain features reminiscent of magnetars. In some of the bright pulses we measure a quasi-periodicity in the sub-pulse components (Figure 1: panels f and g) which at times appear to be harmonically related between pulses. In some others we see multiple quasi-periods within a single rotation. Similar quasi-periodic features have been observed in a sample of fast radio bursts (FRBs) (Figure 1: panels a, b and c).  Interestingly, radio observations of the magnetar XTE J1810−197 following its 2018 outburst revealed a persistent 50-ms periodicity imprinted on the pulse profile.

While PSR J0901-4046 exhibits a range of quasi-periods between single pulses, the most commonly observed quasi-period follows the spin-period scaling seen in corresponding values of the micro-pulses in normal pulsars. However, the appearance of the dropouts (Figure 1: panels f and g) is different to that of normal micro-pulses. In contrast, it is very reminiscent of quasi-periodic oscillation (QPO) features seen both in the emission of hard short X-ray bursts and the tail of energetic giant flares of magnetars and is very unusual for pulsar radio emission. Such quasi-periodic oscillations are also theorized in models of FRBs, where they are due to magneto-elastic axial (torsional) crustal eigenmodes originating close to the neutron star surface. Ultimately, it is unclear what causes the quasi-periodicity in PSR J0901−4046. Global magnetoelastic axial (torsional) oscillations are a tempting explanation, but the persistence of our periodicities would require repeated triggers and/or very long damping times. The observed periodicities and frequencies, however, may be consistent with models proposed for magnetars, and the similarity with the periodic feature of the radio-loud magnetar XTE J1810−197 are intriguing. PSR J0901−4046 is therefore an important piece in the puzzle of the evolution of highly magnetized neutron stars and their connection to FRBs. Continued monitoring of the object will tell us whether it can produce pulses with FRB-like energies similar to what was seen from the Galactic magnetar SGR 1935+2154.

<u>Biography:</u>

Manisha Caleb is presently a Discovery Early Career Researcher Award fellow, and lecturer based at the University of Sydney in Australia specialising in radio transients, particularly fast radio bursts (FRBs). She is involved with collaborations at the MeerKAT and ASKAP radio telescopes to discover, study and understand the enigmatic FRB phenomenon. She is keen on observational studies of FRBs and takes particular interest in their polarisation properties. She continues to lead the international multi-wavelength collaboration to follow-up FRBs discovered with MeerKAT and study their host galaxies. She is currently interested in FRB cosmology and investigating a possible connection between FRBs and the more recently discovered ultra-long period neutron stars.

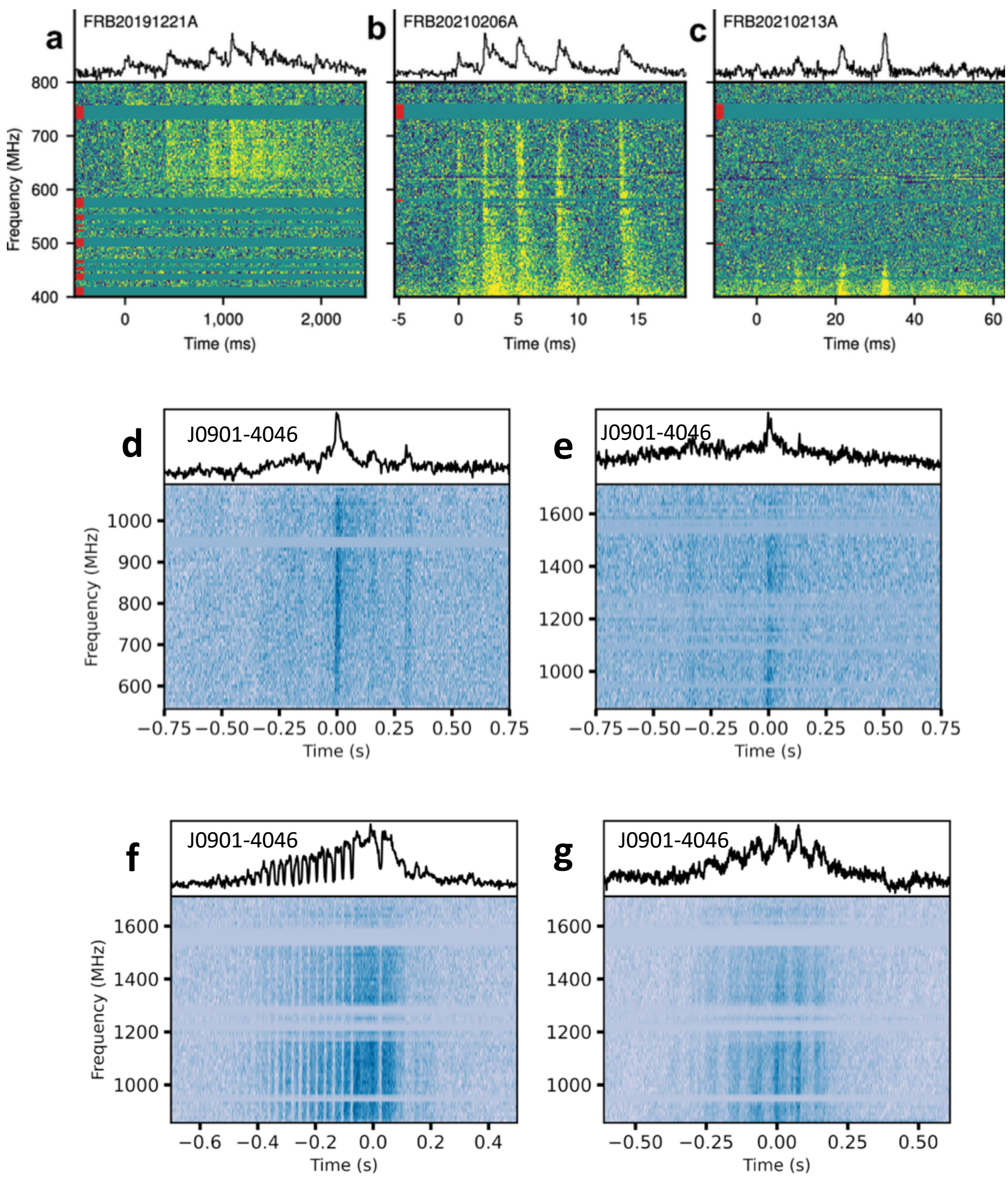


Figure 1: Example quasi-periodic pulses from FRBs (CHIME collaboration. 2022) and PSR J0901-4046