Finding pulsars in high-time resolution images

Research Field
Radio Astronomy

Project Suitability
Honours / Masters / PhD

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Since their discovery over 50 years ago, pulsars have been one of the most intriguing astrophysical phenomena. They are extremely dense objects, built primarily of neutrons (and thence called neutron stars), rotating at rates of up to hundreds of times per second and emitting a beacon of radio emission. The physical mechanisms causing the radio emission still remains to be understood. The full list of pulsar-related discoveries is long; for instance, pulsars have proven as very powerful laboratories for testing Einstein's general relativity, as probes of the interstellar medium and as precise clocks for prospective future detections of low-frequency gravitational waves, and finally the very first extrasolar planets were discovered in a pulsar system. So far over 2500 pulsars have been discovered in our Galaxy. However, the total number of pulsars is expected to be much larger (and not all can be observed from Earth due to their radio beacons not pointing in our direction).

The main goal of this project is to develop and apply image-based techniques for finding new pulsar candidates in high-time resolution imaging data obtainable from low radio-frequency aperture array instruments such as the Murchison Widefield Array (MWA; Tingay et al 2013). These data have been collected in the high-time resolution mode, using the so-called Voltage Capture System (VCS) mode. They can be used to form high-time resolution (< 1 second) images, which can be searched for candidate sources in a variety of ways.

The main goal of this project is to develop suitable algorithms for searching Stokes images (in the I,Q,U,V polarisations) for variable sources, and ranking them by degree of polarisations (pulsars tend to be polarised sources), spectral steepness, and variability properties, in order to select the most promising pulsar candidates for further follow-up observations (with the MWA or high frequency radio telescopes such as Parkes, the GMRT or others). The method has also potential for finding other types of radio transients (including Fast Radio Bursts). With its wide field of view (of the order of 20° x 20°) and extremely radio-quiet location, the MWA is an ideal instrument to develop and test such new techniques of discovering pulsars with low radio-frequency aperture array instruments. The success of these methods would make them directly applicable for pulsar searches planned with the upcoming the Square Kilometre Array (SKA) telescope, which will offer one to two orders of magnitude higher sensitivity, thereby enabling substantially more efficient pulsar and transient searches.

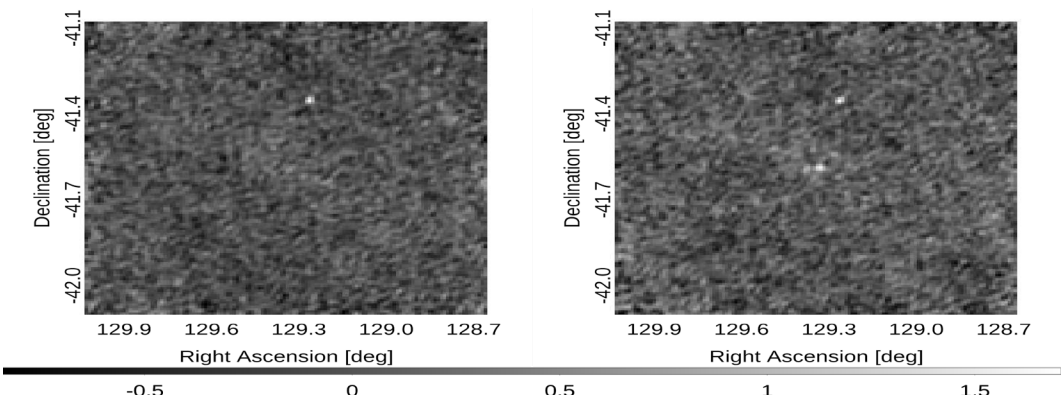

Figure 1. An example of de-dispersed 0.5-second images of pulsar J0837-4135 (left) without a pulse, and (right) with a pulse detected illustrating how transient sources like pulsars can be identified in high-time resolution MWA images.