

# SHAO Low-Frequency Pulsar Search Project Plan

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## 1 Introduction

Pulsar search has been a challenging but exciting activity since it is detected by Jocelyn Bell at Cambridge University in 1967. It was first thought to be unnatural source or signals from aliens, and it was proved to be rapid rotating neutron star later at Arecibo Observatory. It is also a great success for Fritz Zwicky that he predicted the existence of neutron star - a remnant of supernova. Pulsar is a strange and amazing stellar object. It only has a diameter around 11km – half of the size of Manhattan, but a mass of one solar mass. Some of the pulsars have a rotation period of milliseconds, which is called millisecond pulsar. Such a massive and dense object rotating in this high speed with extremely precise period is out of astronomers' imagination. Square Kilometer Array (SKA) will be the largest radio telescope array project probably in this century. Murchison Widefield Array (MWA) - SKA's precursor is providing great amount of data for astronomers to search for more pulsars. Both projects have prioritized pulsar search as one of their main objectives.

## 2 Motivations of Pulsar Search

### 2.1 Test for general relativity

Binary pulsars systems are good laboratories for general relativity. General relativity predicts the existence of gravitational wave which carries the orbital energy of the binary system. Pulsar timing gives accurate period time which is an advantage to measure the change of the orbit precisely. Theoreticians can further modify the theory of gravity and test with pulsar binaries.

### 2.2 Cosmological gravitational wave

The Big Bang event should have left some gravitational wave that travel through space, this is another powerful tool to understand what has happen during the early Universe. The cosmological gravitational wave would influence the pulse arrival timing, which is similar to LIGO. This effect is rather tiny, millisecond pulsar is the key to such a detection. Millisecond pulsars are extremely precise cosmological light houses, they may be the finest clocks in the Universe.

## 2.3 Search for EXO planets

EXO planets becomes a very popular topic in the astronomical society, astronomers discover many buzzard planets that completely differ from the planets in our solar system. The residuals in the pulsar timing are the clues to the planets that orbiting the pulsar, it is fascinating that this method can help to detect earth-like EXO planets, whereas it is difficult for optical spectroscopy.

## 3 Objectives

This summer internship is separated into three stages: re-establish the results in Xue et al. 2017, perform blind search, and evaluate the method of detection.

### 3.1 Stage 1

The first stage is based on the 50 pulsars detected with incoherent sum in Xue et al. 2017. We will use Pulsar Exploration and Search Toolkit (PRESTO) to process fits files in different observation ID (OID) to re-detect ALL 50 pulsars from the paper, this activity will strengthen our confidence in searching pulsars.

### 3.2 Stage 2

The second stage has an assumption that period (P0) and dispersion measure (DM) are unknown; no specific pulsars for the search. Applying similar method learned at stage one while constructing a method to get the appropriate range of DM to search for pulsars.

### 3.3 Stage 3

The third stage is to set guidelines on improving the efficiency of blind search, which aim to contribute to the precursor.

## 4 Current Condition

At the Shanghai Astronomical Observatory (SHAO), PRESTO and other necessary software, i.e. Python, FFTW, tempo have installed. MWA's data is stored in the supercomputer located on site and the cluster can be accessed.

## 5 Schedule

16/7 week	Stage 1 and Pulsars basics
23/7 week	Stage 2
30/7 week	Stage 2, Stage 3 and Wrap up
06/8 week	Summer Schools