The NenuFAR pulsar blind survey

Mark Brionne[1], Jean-Mathias Grießmeier [1,2], Ismaël Cognard [1], Gilles Theureau [1,3], Raphaël Gros [3]
(1) LPC2E - Orléans, (2) Observatoire Radioastronomquie de Nançay, (3) LUTH – Observatoire de Paris

The blind survey program

Pulsars are rapidly rotating neutron stars, with a high surface magnetic field which produces a coherent emission. Due to the angle between the rotation and magnetic axes, there is a lighthouse effect resulting in a periodic pulsation.

The NenuFAR pulsar blind survey *(NPBS hereafter)* has the objective is to observe the entire sky above 39° of declination, using the new radio telescope NenuFAR.

NenuFAR(*) (***n**ew **e**xtension in **N**ançay **u**pgrading LO**FAR***) is a phased array telescope located in the Observatoire Radioastronomique de Nançay. NenuFAR have a diameter of 400 m, and is currently composed of 1 520 antennas which can observe between 10 and 85 MHz.

The aim of the survey is to discover new pulsars, especially close to the Earth, with a relative long period from 100 ms to 30 s, and/or featuring steep spectra.

Expectations

Pulsars have a continuous spectrum in radio, with an increasing flux towards the low frequencies.

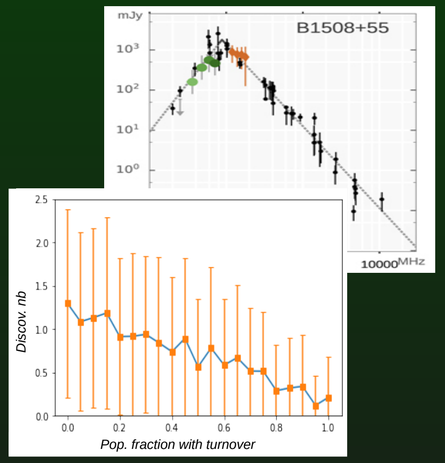
However, it appears that at least an important number of pulsars show a spectral turnover about 100 MHz.

We have made simulations depending on the fraction of the pulsar population with a spectral turnover.

- Averaged expectations for the NPBS:
  - Detections : 81 – 97 pulsars
  - Discoveries : 0 – 3 new pulsars

However, the size of the emission cone of pulsars depend on its period and on the observed frequency. Thus, the number of expected discoveries can be increased.

Due to this fact, the NPBS discoveries expectations can be multiplied, at least, by a **factor 2 or 3**, especially in the case of slow pulsars.



Top : spectrum of PSR B1508+55.
Bottom : number of discoveries taking account of the spectral turnover

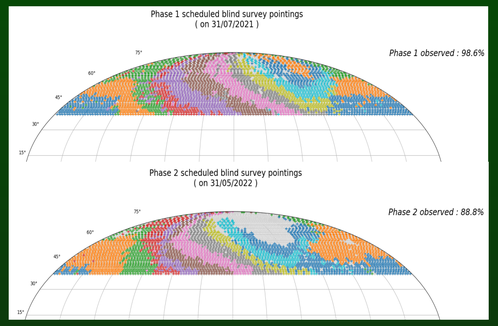
Observing program

The NPBS has begun in August 2020, and the main program is planned to be finished at the end of June 2022.

- NPBS observation characteristics:
  - Used mini-arrays: 25 *(475 antennas)*
  - Angular beam size: ~ 1.2° *(at 58 MHz)*
  - Sky pointings: 7 692
  - Frequency range: 39 – 77 MHz

To optimize the sky coverage, the observing program is divided into 2 successive phases of interleaved beams, where the pointings of the phase 2 are displaced by about a beam radius compared to the phase 1.

- Phase 1 : August 2020 → July 2021
  Complete
- Phase 2 : July 2021 → June 2022
  89% at the 31st May 2022



Progress of the NPBS observations month by month.

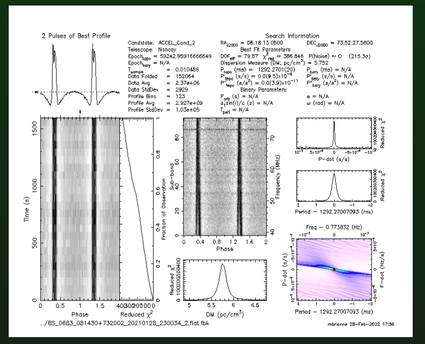
Data processing and redetections

To find pulsars, a searching for a periodic signal is done using a custom processing pipeline based on a Fourier method.

The capacity of detection of the NPBS has been tested by searching if already known (and expected to be detectable) pulsars are found.

- First results :
  - Processing progress : 44 % of the phase 1
  - Expected known pulsars : 4 surely and 4 potential
  - Found pulsar candidates : 19
  - Redetected pulsars : 5 *(1 in the potential)*

Moreover, the 5 redetected pulsars are easily found, and detected with a high significance.



Detection of PSR B0809+74.

Contacts

mark.brionne@cnrs-orleans.fr jean-mathias.griessmeier@cnrs-orleans.fr icognard@cnrs-orleans.fr theureau@cnrs-orleans.fr raphael.gros@obspm.fr

Reference

(*) https://nenufar.obs-nancay.fr/en/astronomer/