

Pulsar Observation and Study with FAST and Parkes Radio Telescope

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Content

- FAST single
 pulse study for
 PSR J1926-0652
- Parkes globular cluster pulsar study with UWL receiver





2017@Parkes site

An introduction

To date, more than 70 pulsar candidates have been identified using the UWB receiver, out of 51 have been confirmed by using Parkes, Effelsberg, Arecibo, Fermi-LAT or FAST self.

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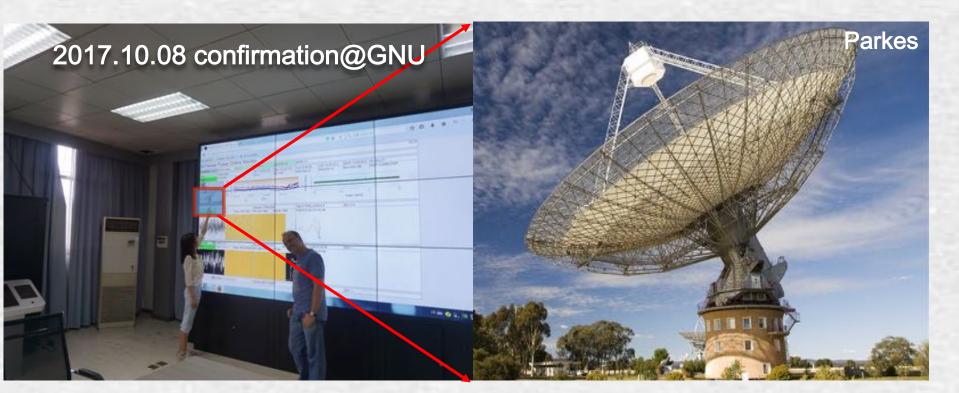


CRAFTS 項目開站: http://erafts.bao.ac.cn/pulsar/

Observations

2017.8: discovered at FAST using a single-pulse pipeline (Zhu et at. 2014)
2017.10: confirmed at Guizhou Normal University using Parkes telescope
2017.10 - 2018.09: continued observations with both FAST and Parkes

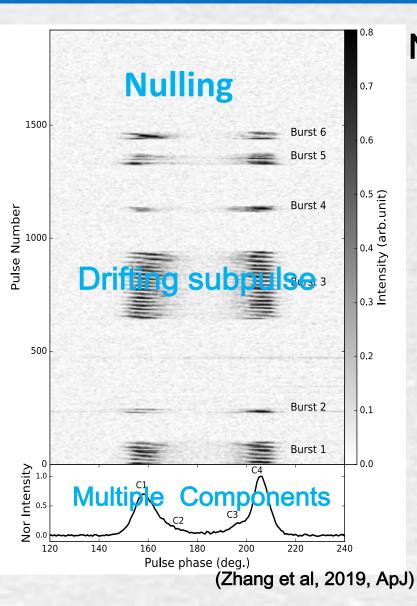
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Emission properties overview

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Nulling Properties of the Pulsar

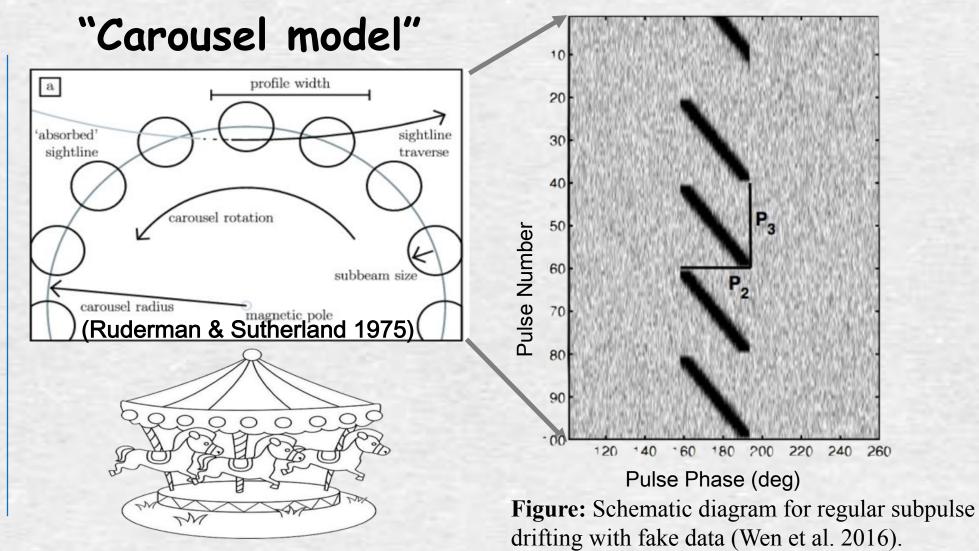
- FAST short-term single-pulse data sets (~50 minutes):
 - null fraction is ~ 75%
 - short-term nulling lasting from 4 to 450 pulses.
- Parkes long-term monitoring observations (~1 yr):
 - the mean flux density at 20cm about 0.8 mJy
 - the average off-state duration of about 20 minutes

Conclusion: Nulling is the likely cause for its being missed by previous searches.

Complex subpulse drift behaviors

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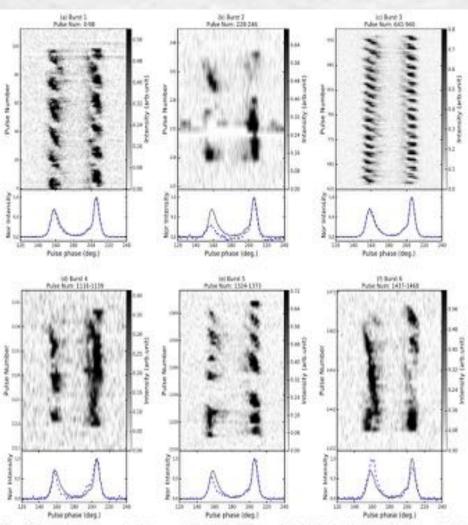


Figure 2. Pulse stacks for each barst are given in the upper panel of such subplot. The lower panel of each subplot shows the pulse postlie averaged over the whole data spot as a Mack solid line and averaged over the particular barst state as a Mac dedied line.

These complexities pose challenges for the classic carousel-type models.

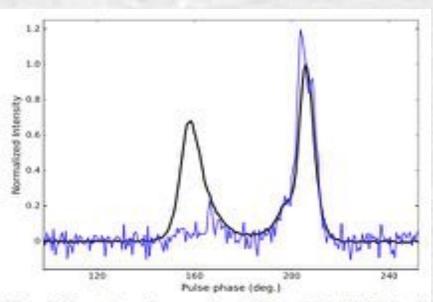


Figure 7. Mean pulse profile averaged over all bursts (thicker black line) and the average profile for the last detectable pulse of each burst (thinner blue line). The mean burst profile peak is normalized to 1.0. The profiles were averaged (Zhang et al, 2019, ApJ)

A summary

FAST single
 pulse study for
 PSR J1926-0652

 Parkes globular cluster pulsar study with UWL receiver "FAST is a very sensitive telescope and it is likely to find a large number of pulsars along with also revealing a plethora of unexplored single pulse behavior previously unseen for many pulsars. PSR J1926-0652 is one such nice example. The paper is written in a clear language and does attempt to cover various aspect of the observed single pulse emission properties..."

-- Comments from the ApJ Anonymous Reviewer



An introduction

- FAST single pulse study for PSR J1926-0652
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P1006_2019APR (approved 106 hours for 11 GCs, PI) The first time wideband observations of pulsars in GCs Strengths:

- Ultra-high time resolution (64us): It will be more sensitive for fast spin pulsars
- Coherently de-dispersed observation corrects for dispersion between channels
- The wide frequency range (704–4032 MHz), along with the well-calibrated system **Goals**:
- Search for new pulsars in GCs: MSPs (e.g. fast spin pulsars, binary systems)
- Wide bandwidth study pulsars in GCs: emission properties (e.g. polarization, flux densities)

Wide Bandwidth Observations of PSRs C, D, and J in 47 Tuc

Overview Pulsars in 47 Tuc (Dec -72°, Distance ~4.5 kpc):

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- To date, all of 25 known MSPs were discovered by Parkes.
- PSRs C, D and J are three brightest pulsars in the 47 Tuc.
- There are no previous wideband or well-calibrated polarization observations of pulsars in 47 Tuc.

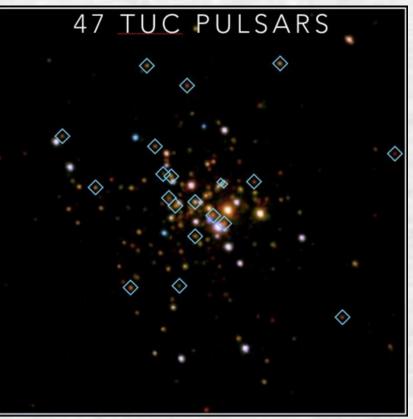
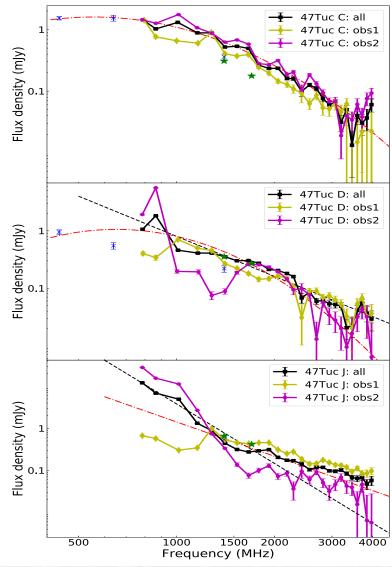


Figure: The pulsars in an X-ray map of 47 Tuc.(Credit: Craig O. Heinke)

Wide Bandwidth Observations of PSRs C, D, and J in 47 Tuc

Main Results in this work:

- Measured calibrated flux densities and spectral properties
 - Updated dispersion measurements
 - Presented polarization pulse profiles along with Faraday rotation measures
 - 799–825 MHz and 970–1260 MHz are the optimal bands for independent pulsar searching with the UWL receiver at Parkes.



(Zhang et al, 2019, ApJL)

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FAST single pulse study for PSR J1926-0652

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• Parkes globular cluster pulsar study with UWL receiver

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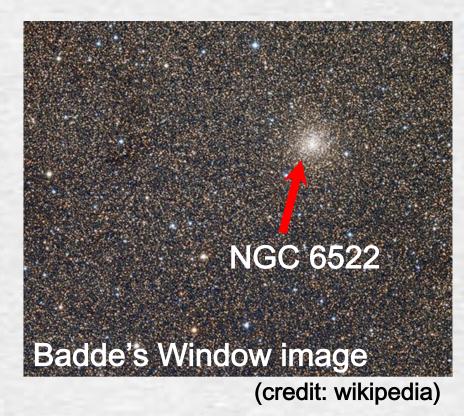
Overview Pulsars in NGC 6522 (Dec -30°, Distance ~7.7 kpc):

- Three MSPs have been found in the cluster by previous pulsar surveys.
- FAST single pulse study for PSR J1926-0652

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- Parkes globular cluster pulsar study with UWL receiver
- PSR J1803–3002A is relatively strong and was discovered in the Parkes Globular
 Cluster survey at 20 cm. The other two pulsars were discovered using the GBT.
- To date, there have been no published longterm timing or polarization observations or flux density measurements for any of these three pulsars – they just have approximate positions, pulse periods and DMs from the search analyses.



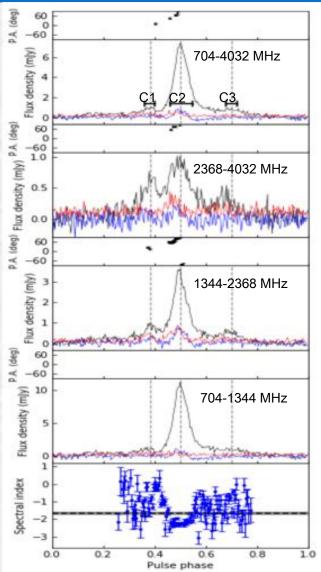
Wideband Monitoring Observations of PSR J1803-3002A in NGC 6522

Main Results from in this work:

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 PSR J1926-0652
- Parkes globular cluster pulsar study with UWL receiver

We present the timing solution and describe the emission properties of PSR J1803–3002A for the first time.

- It is a distant pulsar in the Galactic plane, but there is no evidence of pulse broadening due to interstellar scattering in our observations.
- No linear polarization was detectable in the lowest RF band (704–1344MHz) band.
- The over-all radio spectral index for pulsar, -1.66±0.07, is somewhat flatter than -2.0, the mean spectral index for MSPs.



(Zhang et al, 2020, submitted to ApJL)

3 Discovery of the "hidden" MSP in the NGC 6397?

Overview Pulsars in NGC 6397 (Dec -53°, Distance ~2.3 kpc)

 FAST single pulse study for PSR J1926-0652

Parkes globular cluster pulsar study with UWL receiver

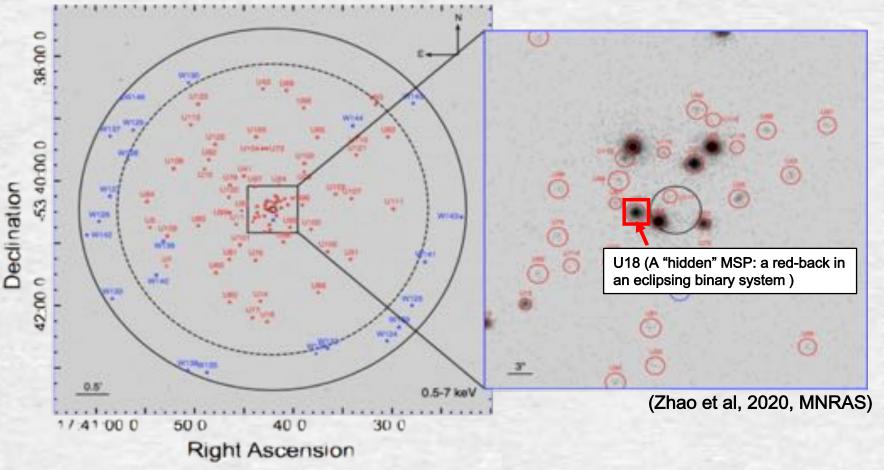
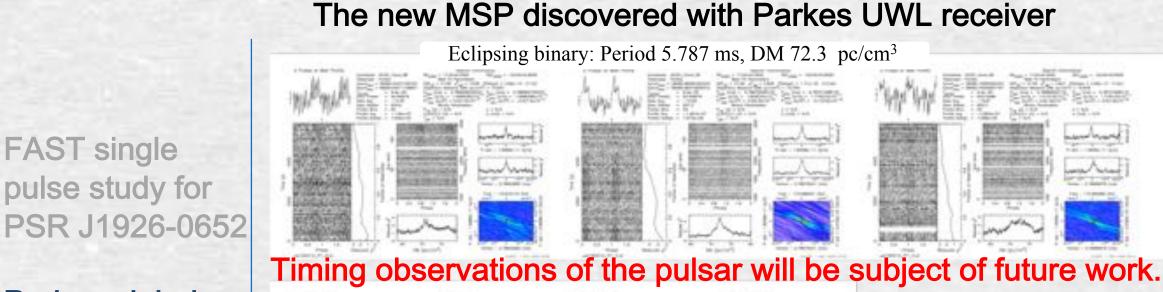


Figure. *Left*: 0.5-7 KeV X-ray image of 6'.6×6'.6 square region centered on the cluster. *Right*: A zoom-in 45"×45" square region centered on the cluster. The solid black circle shows the 0.05' core radius.

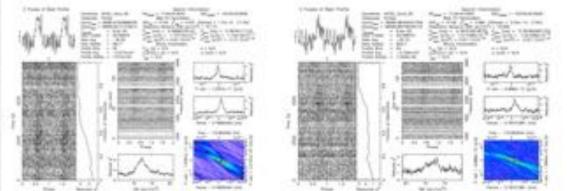
3 Discovery of the "hidden" MSP in the NGC 6397?



Parkes globular cluster pulsar study with UWL receiver

FAST single

pulse study for



Plan to propose: MeerKAT, Fermi to do follow-up timing.

Figure. The discovery diagnostic plot of the new MSP in the NGC 6397 out of six 1.7 hour time blocks PRESTO accelsearch. (Zhang et al, 2020, in prepare)

A summary

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 Parkes globular cluster pulsar study with UWL receiver "This is a nice, straightforward paper that shows the power of the new ultra-wideband receiver at Parkes for pulsar observations. There have never been observations like this before, and it is great to see some early results come out on these globular cluster pulsars."

-- Comments for Zhang et al. (2019, ApJL) from Reviewer Scott Ransom



Conclusion

A joint study with FAST and Parkes provide significant capability to study radio pulsars. Main results to today:

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 FAST single pulse study for PSR J1926-0652

 Parkes globular cluster pulsar study with UWL receiver PSR J1926-0652: A Pulsar with Interesting Emission Properties Discovered at FAST

Lei Zhang^{1,2,3}, Di Li^{1,2,4}, George Hobbs^{1,3}, Crispin H. Agar⁵, Richard N. Manchester³, Patrick Weltevrede⁵, William A. Coles⁶, Pei Wang¹, Welwei Zhu¹, Zhigang Wen⁷, Jianping Yuan⁷, Andrew D. Cameron^{1,3}, Shi Dai^{1,3}, Kuo Liu^{1,8}, Qijun Zhi^{9,10}, Chenchen Miao^{1,2}, Mao Yuan^{1,2}, Shuyun Cao⁴, Li Feng⁴, Hengqian Gan⁴, Long Gao⁴, Xuedong Gu⁴, Minglei Guo⁴, Qiaoli Hao⁴, Lin Huang⁴, Peng Jiang⁴, Chengjin Jin⁵, Hui Li⁷, Qi Li⁷, Qi Sheng Li⁴, Hongfei Liu⁶, Gaofeng Pan⁴, Zhichen Pan⁴, Bo Peng⁴, Hui Qian⁴, Lei Qian⁴, Xiangwei Shi⁴, Jinyou Song⁴, Liqiang Song⁴, Caihong Sun⁴, Jinghai Sun⁴, Hong Wang⁴, Qiming Wang⁴, Yi Wang⁴, Xiaoyao Xie⁴, Jun Yan⁴, Li Yang⁴, Shimo Yang⁴, Rui Yao⁴, Dongjun Yu⁴, Jinglong Yu⁴, Youling Yue⁴, Chengmin Zhang⁴, Haiyan Zhang⁴, Shuxin Zhang⁴, Aixonian Zheng⁴, Aiying Zhou⁴, Boqin Zhu⁴, Lichun Zhu⁴, Ming Zhu⁴, Wenbai Zhu⁴, and Yan Zhu⁶

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https://doi.org/10.3847/1538-4357/ab1849



Wide Bandwidth Observations of Pulsars C, D, and J in 47 Tucanae

Lei Zhang^{1,2,3}, George Hobbs^{1,3}, Richard N. Manchester³, Di Li^{1,2,4}, Pei Wang¹, Shi Dai^{1,3}, Jingbo Wang⁵, Jane F. Kaczmarek³, Andrew D. Cameron^{1,3}, Lawrence Toomey³, Weiwei Zhu¹, Qijun Zhi^{6,7}, Chenchen Miao^{1,2}, Mao Yuan^{1,2}, Songbo Zhang^{2,3,8,9}, and Zhenzhao Tao^{1,6,7}

WIDEBAND MONITORING OBSERVATIONS OF PSR J1803–3002A IN THE GLOBULAR CLUSTER NGC 6522 (Zhang et al, 2020, submitted to ApJL)

Lei Zhang^{1,2,3,4*}, Richard N. Manchester², Andrew D. Cameron², George Hobbs^{2,3}, Di Li^{3,5*}, Shi Dai², Qijun Zhi^{4,6}, Zonghong Zhu¹, Jingbo Wang^{7,8,9}, Lawrence Toomey², Yi Feng^{3,2}, Shuangqiang Wang^{7,2}, Songbo Zhang¹⁰

An New Eclipsing Binary MSP in NGC6397

(Zhang et al, 2020, in prep.)

Future work

- FAST single
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 PSR J1926-0652
- Parkes globular cluster pulsar study with UWL receiver



