Discovery of Millisecond Pulsar and Transient Emission in Glimpse-C01

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Introduction

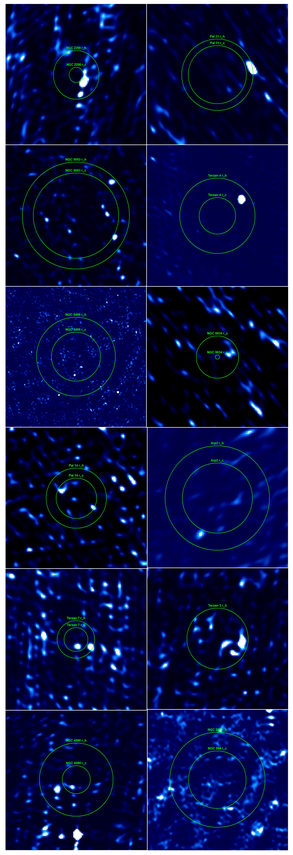
Motivations:

- Search for pulsars in globular clusters
- Pulsation searches are often ineffective due to factors such as binary acceleration and dispersion
- Searching for steep spectrum radio sources is an effective alternative
- The commensal VLA 340 MHz, VLITE, data enables the detection of pulsar candidates

Methods

The VLA Low-band Ionosphere and Transient Experiment (VLITE) is a wide band low frequency receiver centered at a frequency of 340 MHz that operates simultaneously with the VLA. Using VLITE data provides us with an advantage because low frequency measurements are ideal for detecting pulsars due to their steep spectral indices.

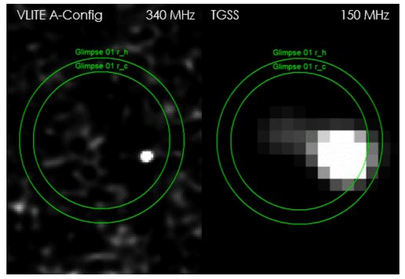
- First, we compiled a list of globular clusters without previously identified pulsars using the Harris and Freire catalogs.
- 94 clusters were then analyzed using VLITE images from standard observations and from the VLITE Commensal Sky Survey (VCSS).
- Numerous different sky surveys were used to determine the spectral index, including VLASS, NVSS, RACS, SUMSS, GLEAM, and TGSS, which operate at 3GHz, 1.4GHz, 890 MHz, 850 MHz, 200 MHz, and 150 MHz, respectively.
- Hubble Space Telescope images were used to look for optical counterparts.
- We searched for X-ray emission using Chandra data.



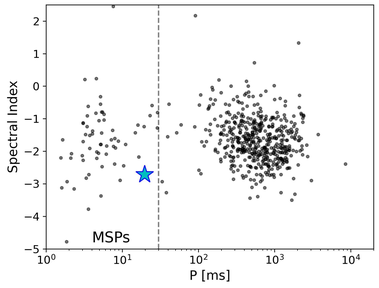
Above: VLITE and VCSS images of globular clusters containing sources

New Millisecond Pulsar

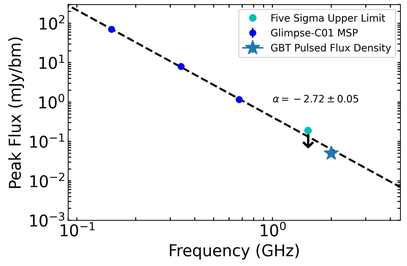
- In the cluster Glimpse-C01 we discovered a promising candidate in VLITE and TGSS images (McCarver et al. 2022, in prep)
- Preliminary calculations indicate that the spectral index is approximately -2.7, which is within the expected range for pulsars



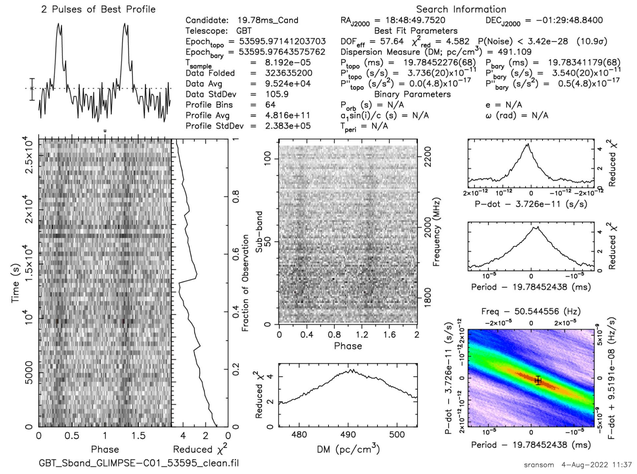
Above: Pulsar candidate observation in VLITE A-configuration image over a central frequency of 340 MHz and The GMRT Sky Survey-ADR1 image over a central frequency of 150 MHz



Above: PSRs in the ATNF Catalog spectral index vs pulse period. The Glimpse-C01 pulsar is indicated with a blue star. Note the wide distribution of pulsar spectral indices - not all are steep spectrum.



Above: Pulsar spectrum from the peak flux measurements from TGSS-ADR1 (151 MHz), VLITE (340 MHz), GMRT (675 MHz), and JVLA (1520 MHz) images. Pulsed flux from GBT S-band. The spectral index is approximately $\alpha = -2.7$ where $S(\nu)$ is proportional to ν^{α}

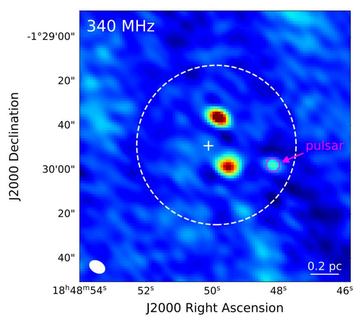


Above: Presto detection of new pulsar from GBT S-band data

- Re-processed 2005 GBT S-band data with acceleration and large dispersion range
- Detected a millisecond pulsar in a binary, with a pulsed flux of ~ 50 μJy
- Highlights the importance of archival data and emphasizes the role of commensal low-frequency radio data in new pulsar searches

Discovery of Transient Emission

- MAXI J1848-015, a December 2020 X-ray outburst associated with a central black hole (white cross) in Glimpse-C01
- VLITE detected two new radio sources in April 2022 (figure right, Peters et al. in prep)
- The new radio emission may be caused by jets from the black hole outburst



Conclusion and Future Work

- The confirmation of a pulsar within the cluster demonstrates that searches for steep spectrum sources as pulsar candidates are effective in areas of high dispersion
- We searched a total area of about 0.13 degrees squared, and the expected number of background sources is approximately 7.3 based on the extragalactic source counts. In our images, we found 12 sources. The excess of sources suggests that more of these objects could be of galactic origin.
- Proposed for follow-up data with the GBT, VLA, and GMRT

References and Acknowledgements

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