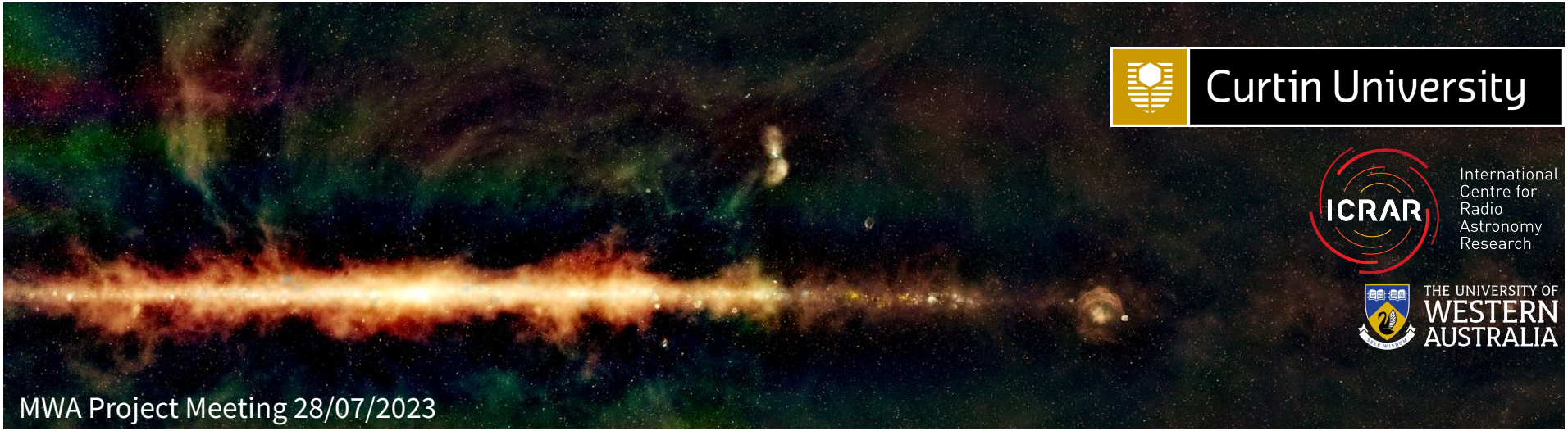
Long-period radio transients

Natasha Hurley-Walker Senior Lecturer, ARC Future Fellow

Gemma Anderson, Arash Bahramian, Ewan Barr, **Ramesh Bhat**, Manisha Caleb, Tracy Clarke, Tim Galvin, Simona Giacintucci, **Paul Hancock**, Ian Heywood, *Csanad Horvath*, Scott Hyman, Emil Lenc, **Sam McSweeney**, **Bradley Meyers**, **John Morgan**, *Tyrone O'Doherty,* **Danny Price**, Kaustubh Rajwade, Nanda Rea, Ben Stappers, **Andrew Williams**, Francesco Coti Zelati, Xiang Zhang



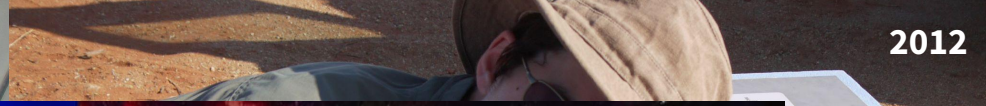

2011


2012


2013

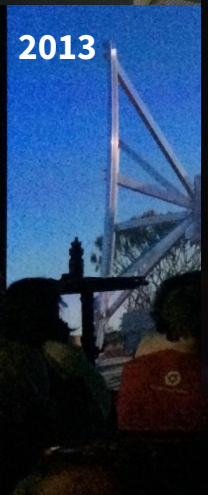

2014
CRAY
PAWSEY
supercomputing centre


2011
2012
2016
TEDxPerth
2013
2014



FT190100231	Dr Natasha Hurley-Walker	Curtin University	eXtending the GLEAM view of the Universe	$857,533	31/12/2024

2019



GLEAM-X J162759.5-523504.3

Article

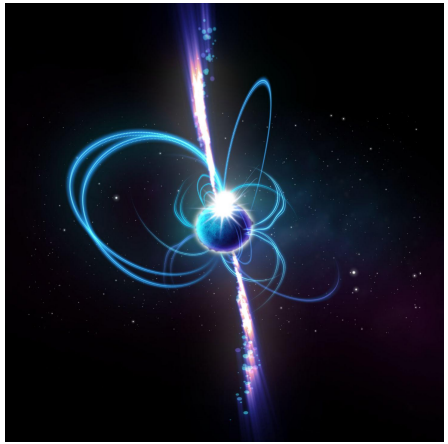
A radio transient with unusually slow periodic emission

https://doi.org/10.1038/s41586-021-04272-x
Received: 30 July 2021
Accepted: 19 November 2021
Published online: 26 January 2022
Check for updates

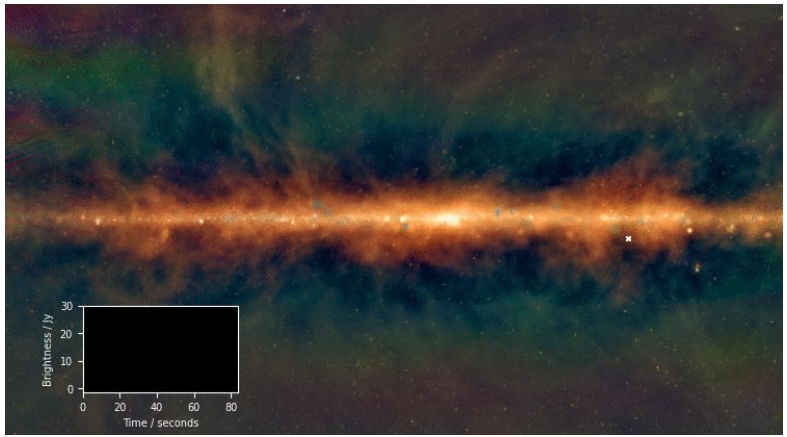
N. Hurley-Walker[1✉], X. Zhang[2,3], A. Bahramian[1], S. J. McSweeney[1], T. N. O'Doherty[1], P. J. Hancock[1], J. S. Morgan[1], G. E. Anderson[1], G. H. Heald[2] & T. J. Galvin[1]

The high-frequency radio sky is bursting with synchrotron transients from massive stellar explosions and accretion events, but the low-frequency radio sky has, so far, been quiet beyond the Galactic pulsar population and the long-term scintillation of active galactic nuclei. The low-frequency band, however, is sensitive to exotic coherent and polarized radio-emission processes, such as electron-cyclotron maser

- "On" for 30 — 60 s
- Repeats every **18.18 minutes**
- *S* ~ **20 — 50 Jy**
- **90%** linearly polarised
- Active Jan - Mar 2018 (and never again!)

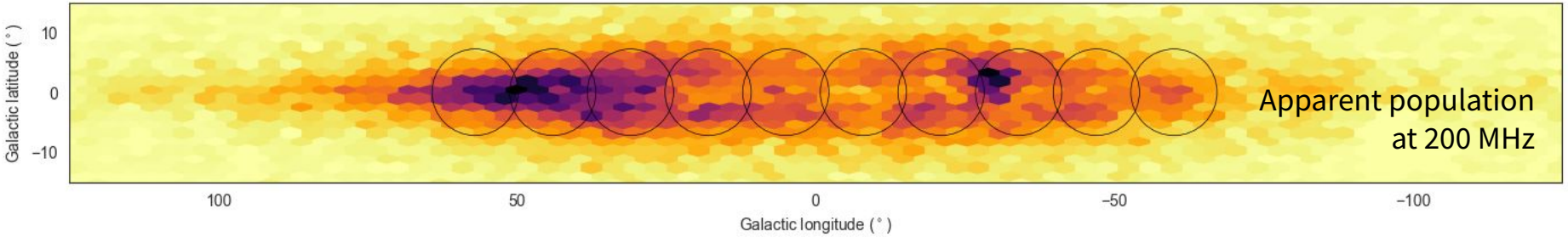


- Hons student project: Tyrone O'Doherty
- Co-supervised by Paul Hancock
- A technique test: no expectations



b = -2.6°

Galactic Plane Monitoring (GPM; G0080)



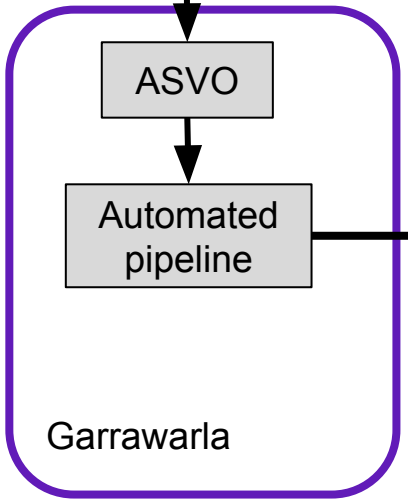
10x 30-minute pointings

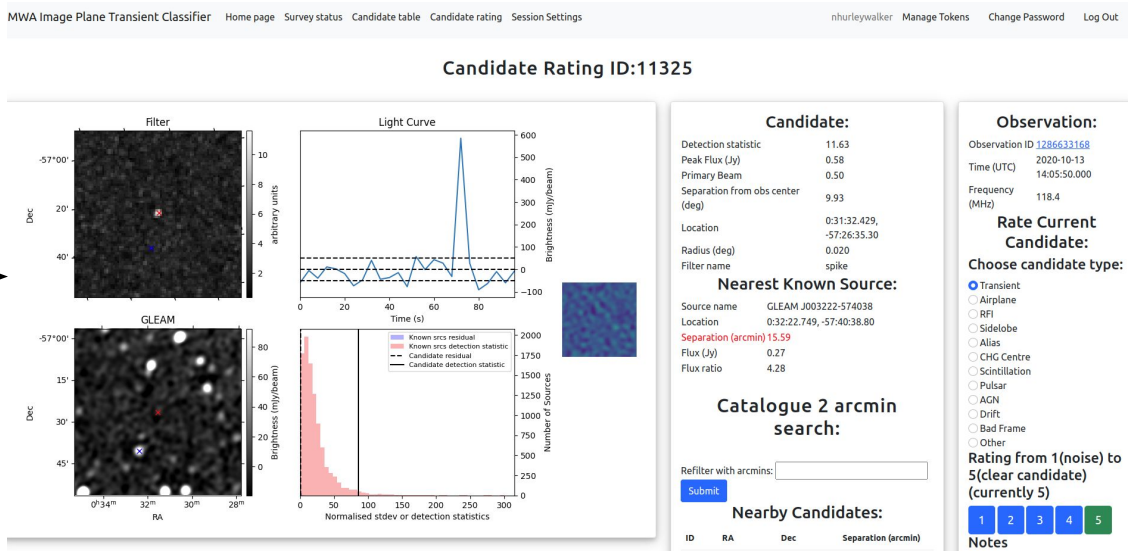
Revisit every 3 days

June to September 2022

Finding transients

Csanad Horvath (3rd year), Nick Swainston (ADACS),
Tim Galvin, John Morgan





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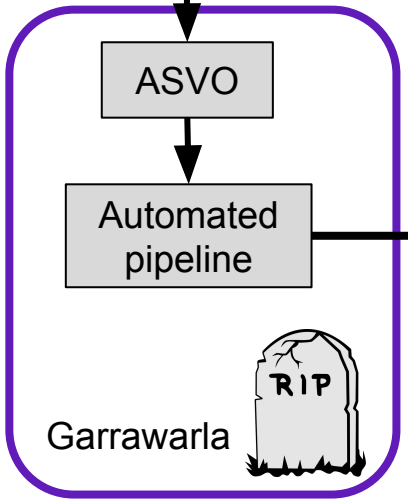

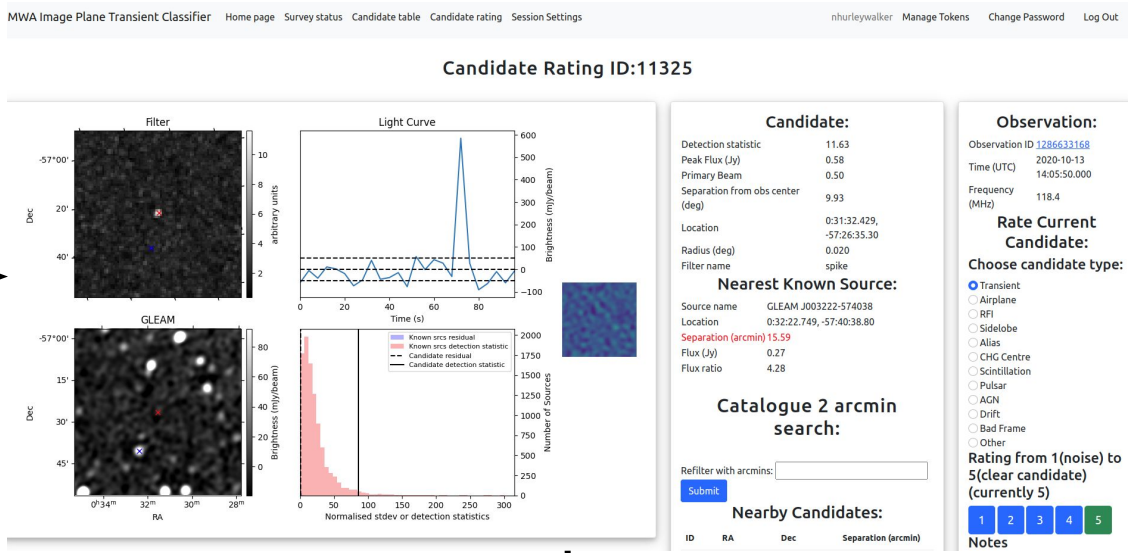

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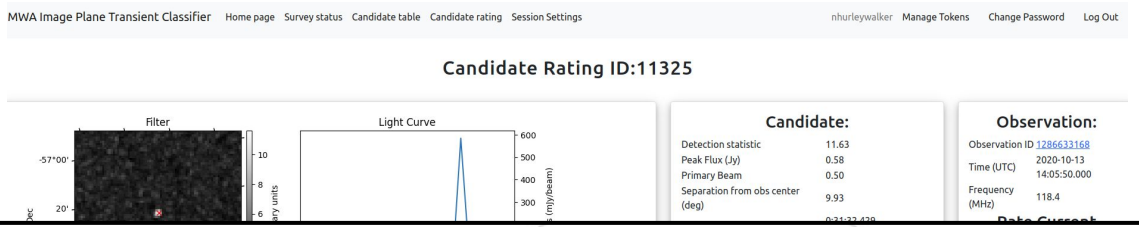


Tuesday, July 12th

Natasha 4:06 PM

😱😱😱😱😱😱 https://mwa-image-plane.duckdns.org/candidate_rating/739/ 😱😱😱😱😱😱😱

Tim Galvin 4:17 PM

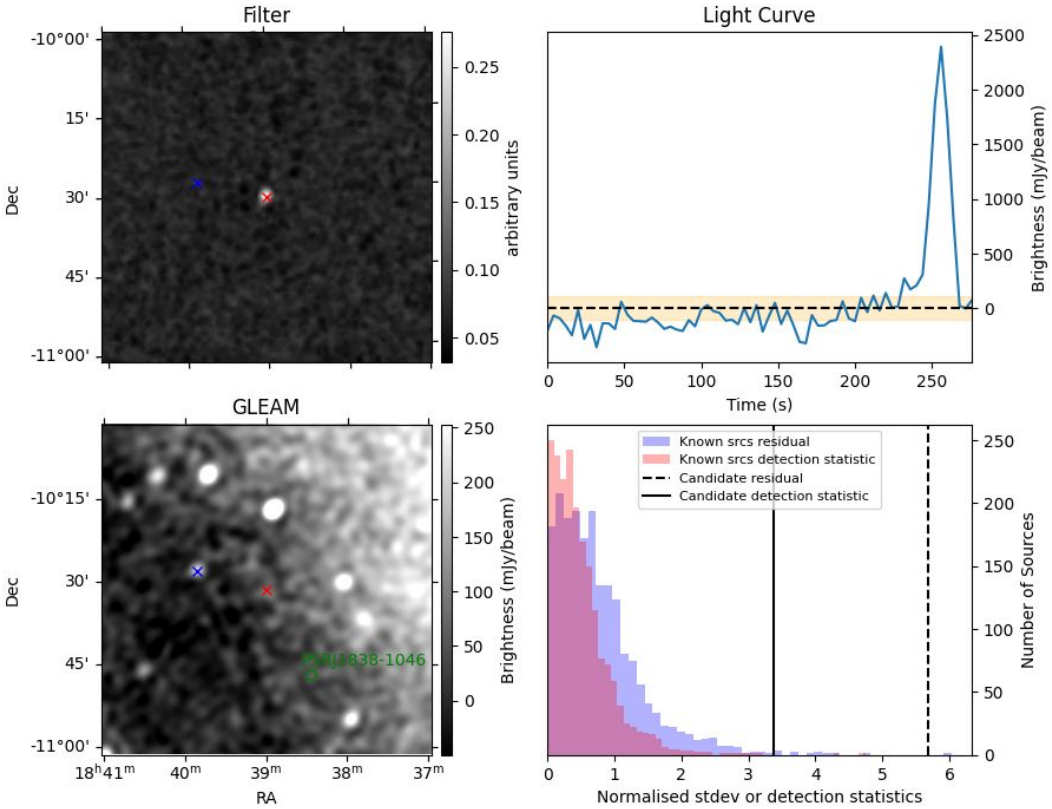
BOOOMMM

THAT looks NICE

Automated pipeline

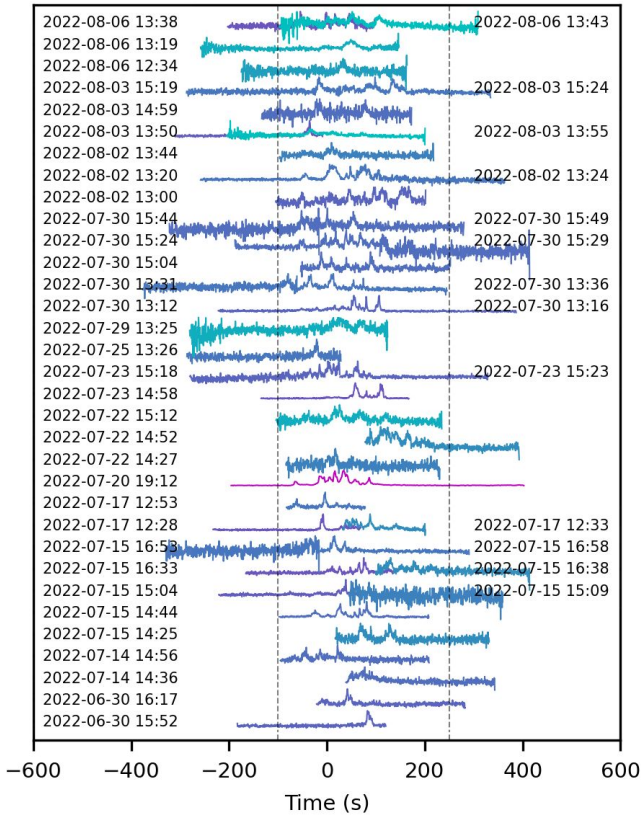
Garrawarla

GPM J1839-10



5-min observation
4-s time steps

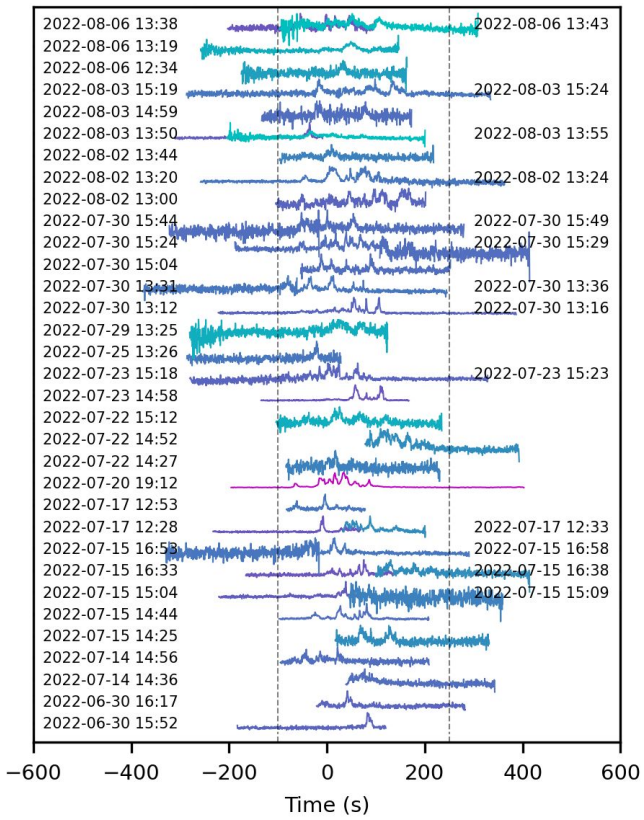
Another periodic transient!



GPM J1839 -10

P ~ 1318s

Another periodic transient!



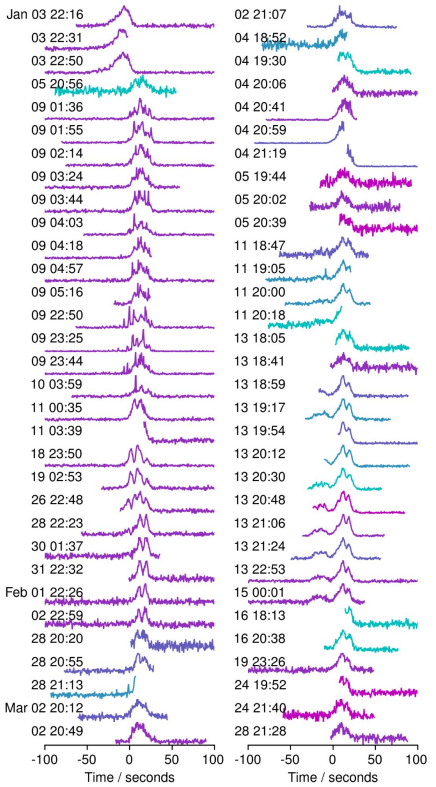
GPM J1839 -10

P ~ 1318s

Compared to J1627:

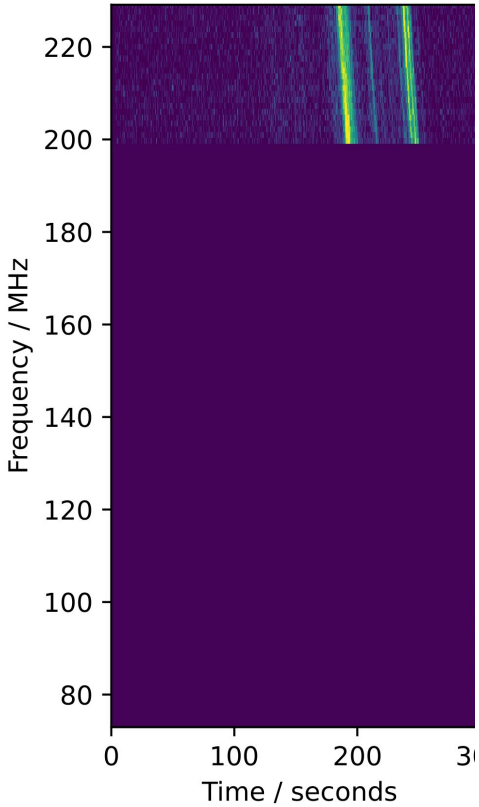
- Intermittent
- Much wider pulses (up to 400s)
- Variable pulse morphology

P ~ 1090s

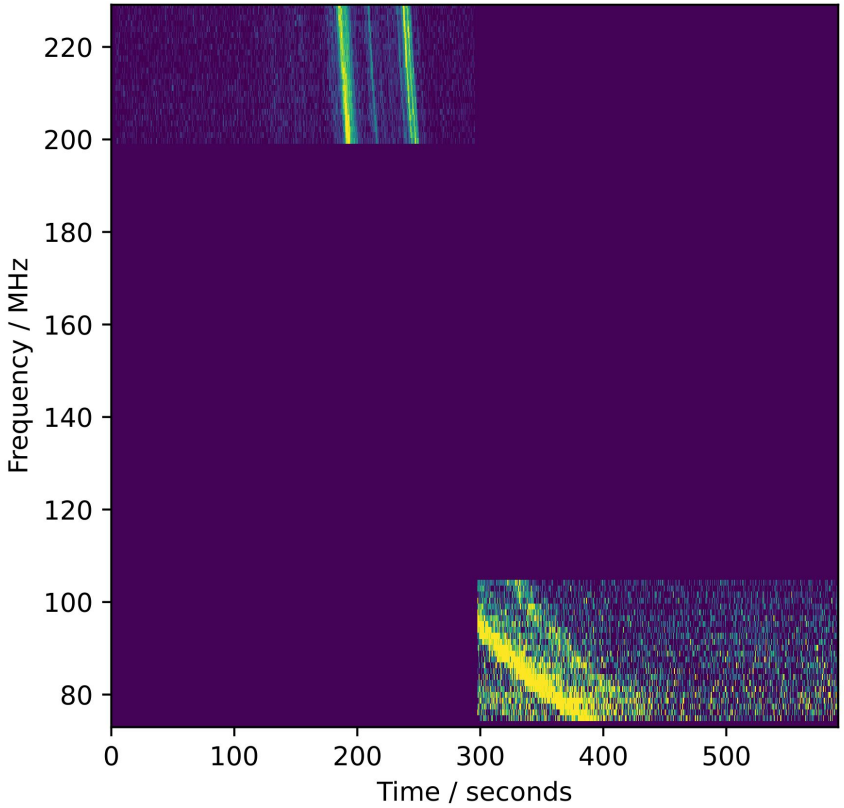


GLEAMX J162759.5-523504.3

Dispersion and distance



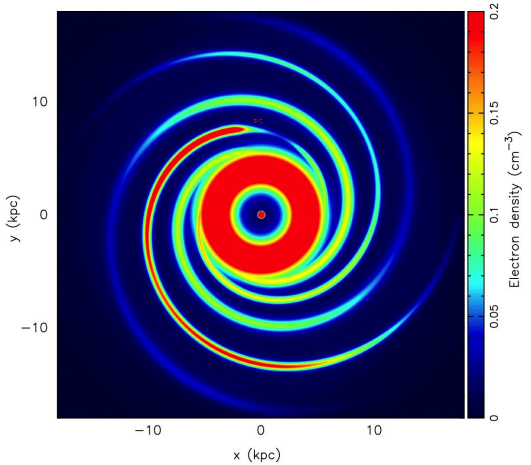
Dispersion and distance



DM ~ 275 pc cm^{-3}

D ~ 5.8 kpc

YMW 2017



Scattering timescale at 80 MHz ~ 60s!

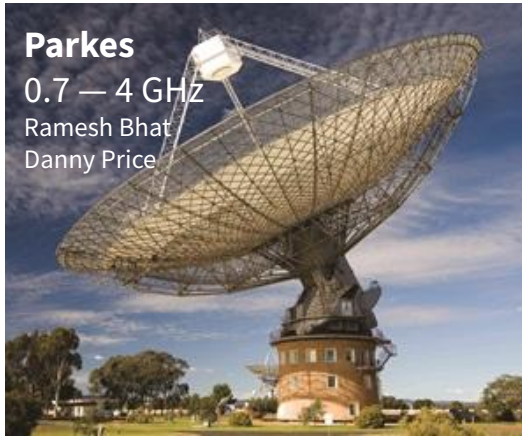
Follow-up


MWA
72 — 231 MHz
Tim Galvin
Csanad Horvath
Andrew Williams


MeerKAT
500 — 1000 MHz
Ewan Barr, Manisha Caleb, Ian Heywood,
Yunpeng Men, Kaustubh Rashwade, Ben
Stappers

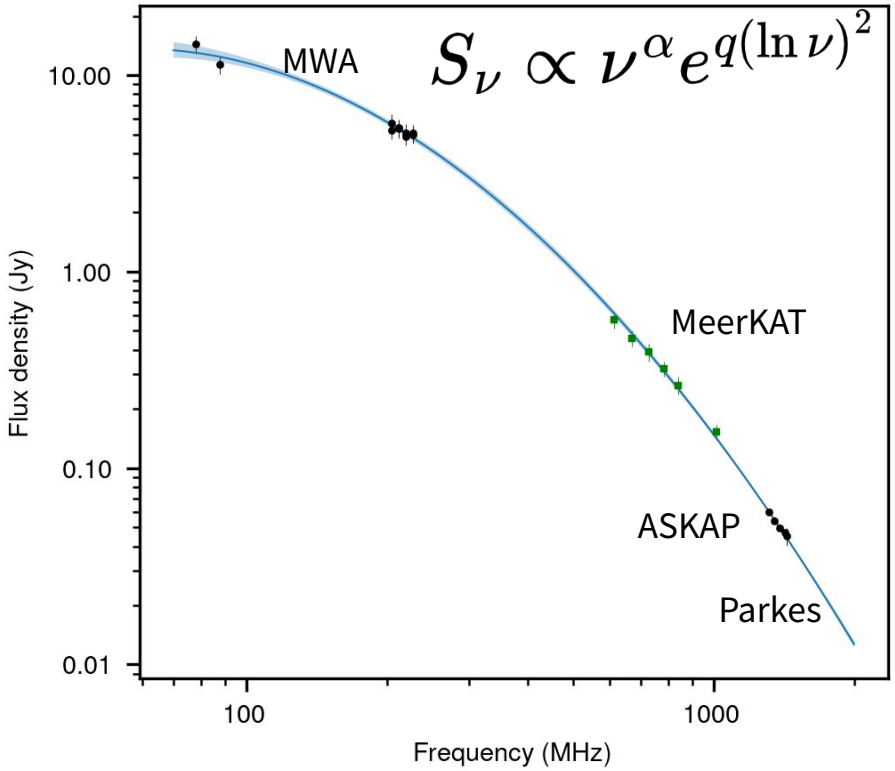

UTMOST
805 — 860 MHz
Chris Flynn
Matthew Bailes


ASKAP
0.5 — 1 GHz
Emil Lenc
Vanessa Moss


Parkes
0.7 — 4 GHz
Ramesh Bhat
Danny Price

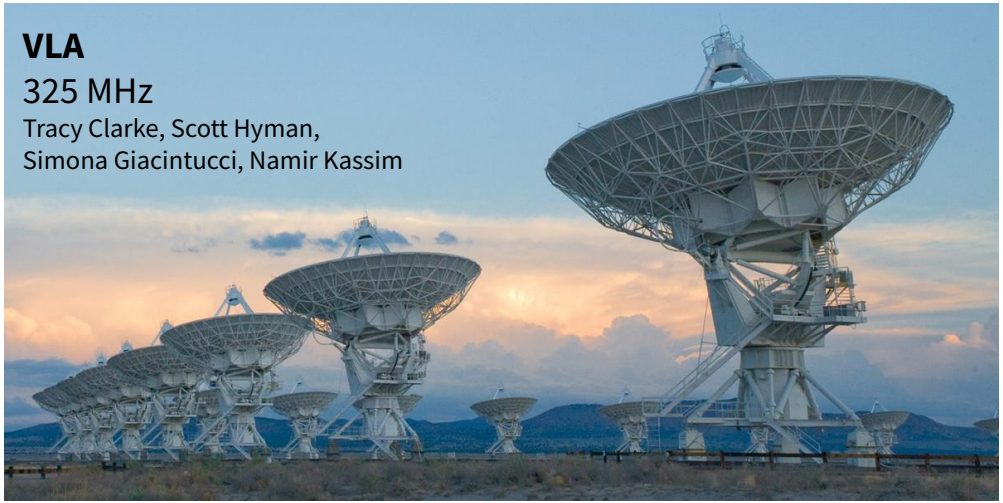

ATCA
5 — 9 GHz
Gemma Anderson
Tim Galvin

Success!



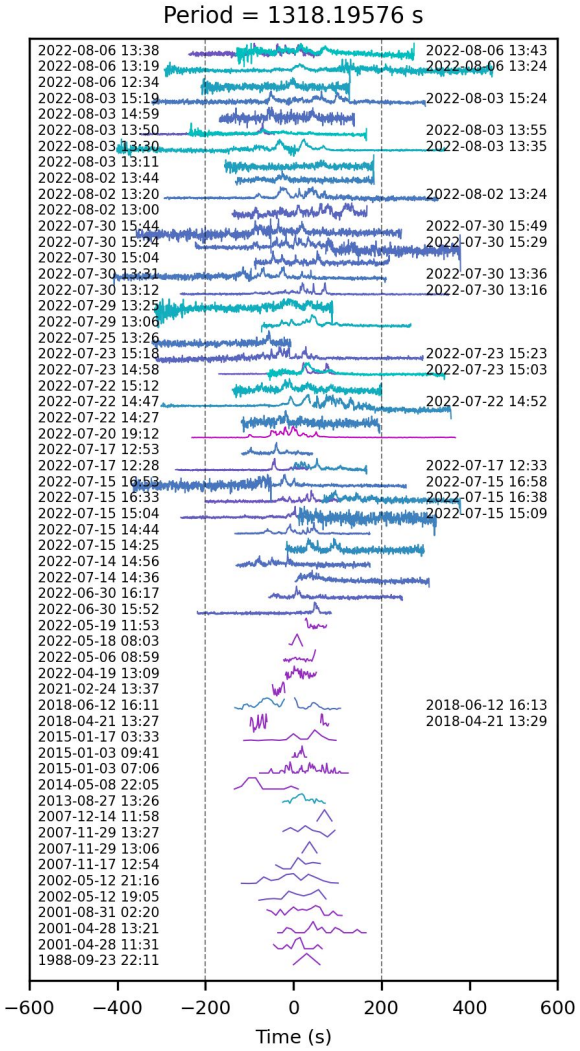
L_{radio} ~ 10^{28} erg/s

Archival search



Further success!

Detections over >33 years



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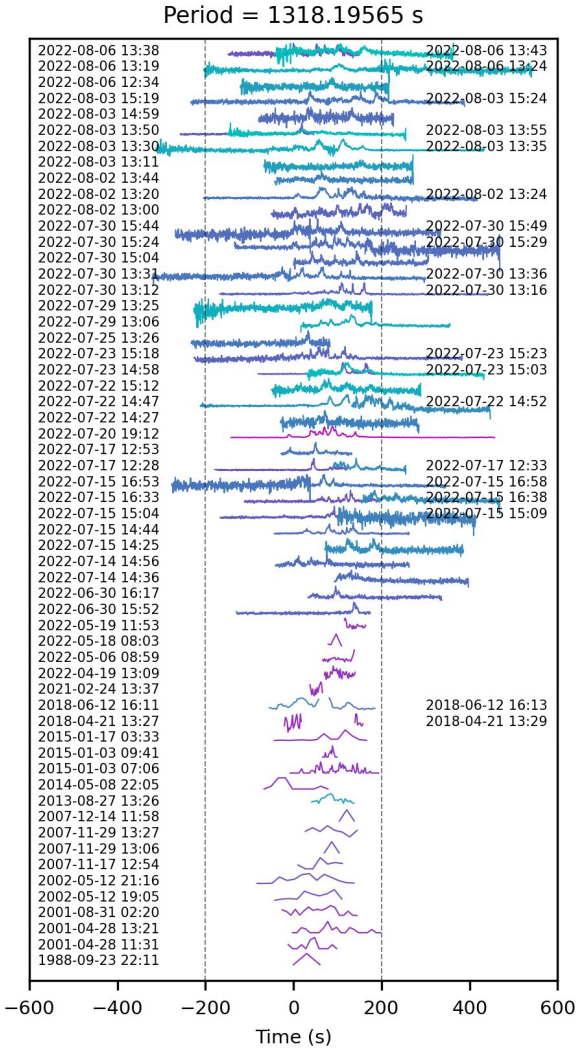


Further success!

Detections over >33 years

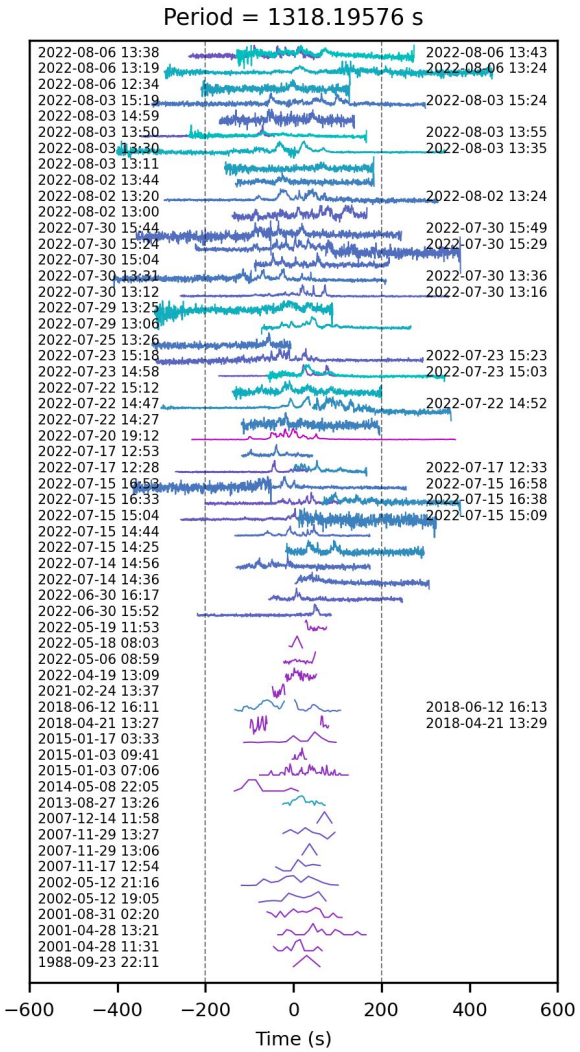
→ constraint on period derivative

$$\dot{P} < 4 \times 10^{-13} \mathrm{s\,s^{-1}}$$

And spin-down luminosity

$$L_{\mathrm{spin}} = \frac{4\pi^2 I \dot{P}}{P^3}$$

$$L_{\mathrm{spin}} < 10^{24} \mathrm{ergs^{-1}}$$



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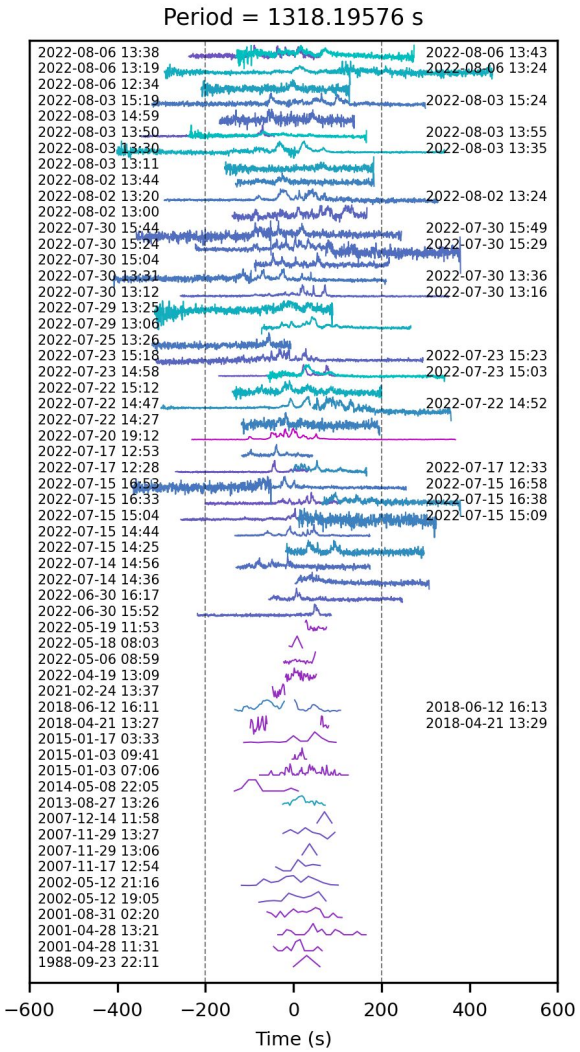
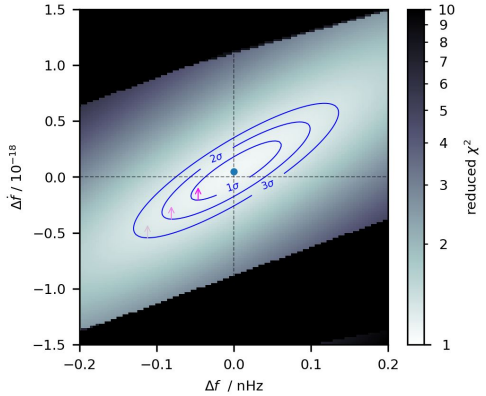
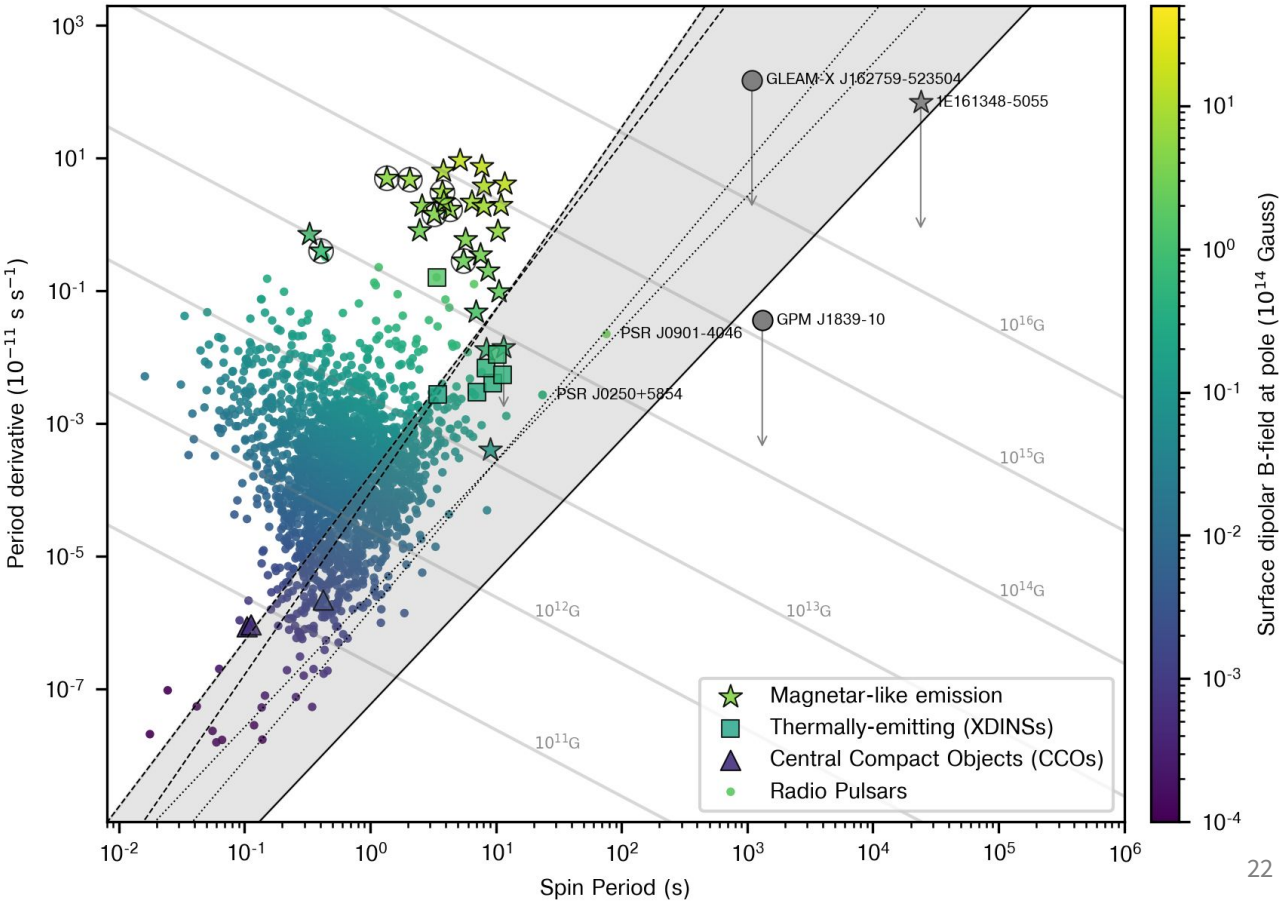
c/f $L_{radio} \sim 10^{28}$ erg/s !



Crossing the death lines



Ask me about interpretations!



Are aliens trying to contact Earth? Scientists discover a mysterious stellar object that emits a five-minute pulse every 22 minutes – and they have no idea what it is

- **The magnetar is 15,000 light-years away from Earth in the Scutum constellation**
- **Experts say this 'remarkable' stellar object is only the second of its kind detected**

By SAM TONKIN FOR MAILONLINE
UPDATED: 01:38 AEST, 20 July 2023

If **aliens** were to contact Earth, what would it sound like?

Such a scenario has been imagined countless times in science fiction but in reality we have no proof extraterrestrials even exist.

That hasn't dampened the excitement that an advanced civilisation might be out there, however, and the discovery of a mysterious stellar object which emits a five-minute pulse every 22 minutes will only serve to intensify that.

Daily Mail
AUSTRALIA

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A rare, mysterious radio source is stumping astronomers

This distant object has been flashing a signal for three decades. It might be a magnetar, a white dwarf — or something entirely new.

By Elizabeth Gamillo | Published: July 24, 2023

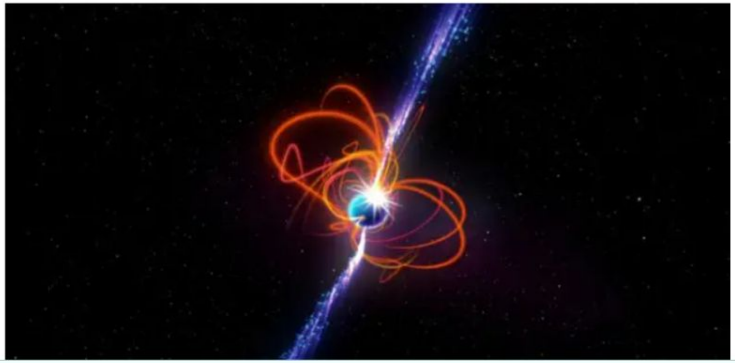

image001.png

In 1988, radio telescopes picked up a transient signal from
15,000 light-years away within the constellation Scutum. E
it remained unnoticed for three decades. Fast-forward to
today: Astrophysicists have recently rediscovered the obje
to find that its source may be a magnetar — a rare type of
neutron star with a powerful magnetic field that sends ene
into space as it spins. Named GPM J1839-10, this star
displays behavior unlike any previously noted.

All other known magnetars have speedy periods ranging fr

EXCLUSIVE: UN warns brain chips like Elon Musk's Neuralink could be used as 'personality-altering' weapons -...

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A Mysterious Object in Deep Space Has Blinked Every 22 Minutes for Over 30 Years

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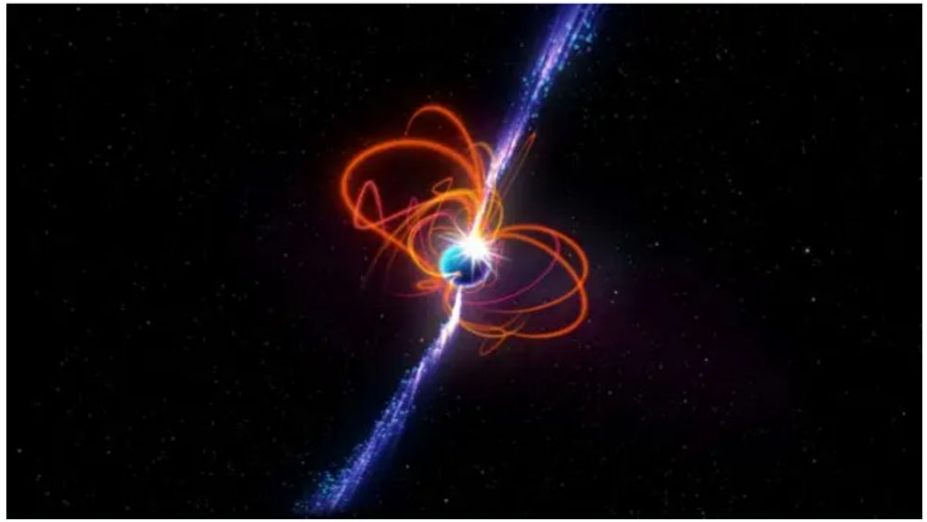
By Elizabeth

Isaac Schultz
Published 1 week ago: July 21, 2023 at 12:03 pm



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A Mysterious Object in Deep Space Has Blinked Every 22 Minutes for Over 30 Years

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By Elizabeth

Isaac Schult
Published 1

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SLOW BURN —

Something in space has been lighting up every 20 minutes since 1988

We have no explanations for this sort of slow repeat.

JOHN TIMMER - 7/20/2023, 3:09 AM

Daily Mail
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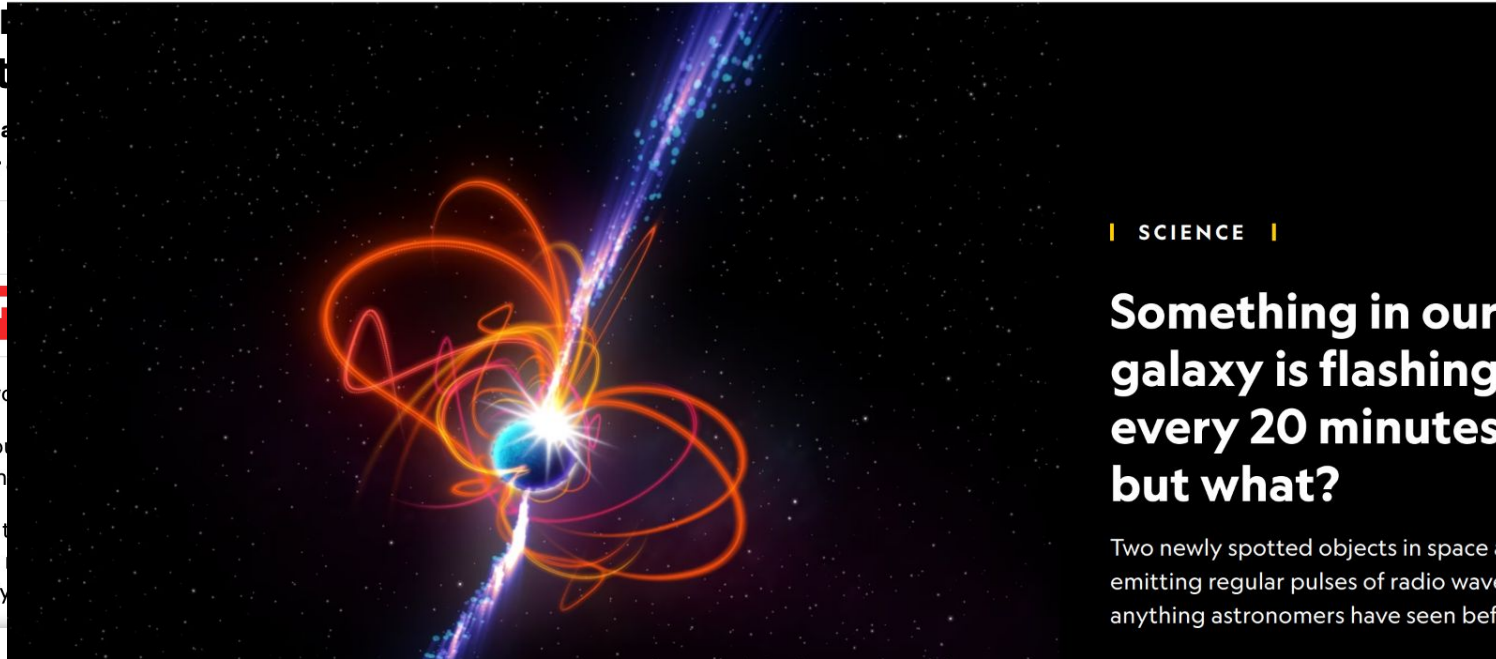

SCIENCE

Something in our galaxy is flashing every 20 minutes but what?

Two newly spotted objects in space
emitting regular pulses of radio wav
anything astronomers have seen bef

Why did the MWA discover these first?

Why did the MWA discover these first?

Field-of-view

Performing the GPM would have taken

- ASKAP: 200 hours per night
- MeerKAT: 6,000 hours per night
- Parkes: 24,000 hours per night

Why did the MWA discover these first?

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Frequency coverage

- 200 MHz for detection (covers most of Milky Way, minimal scattering)
- 72 — 231 MHz for characterisation
- 100% fractional bandwidth = interesting physics!

Why did the MWA discover these first?

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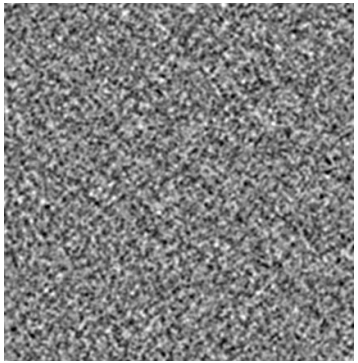
- ASKAP: 200 hours per night
- MeerKAT: 6,000 hours per night
- Parkes: 24,000 hours per night

***(u,v)*-coverage**

➔ extremely uniform noise

➔ Very easy to detect real signals



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Why did the MWA discover these first?

Broad scientific expertise

Why did the MWA discover these first?

Broad scientific expertise

Supercomputing culture

Why did the MWA discover these first?

Broad scien

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Broad scien

Toy modelling

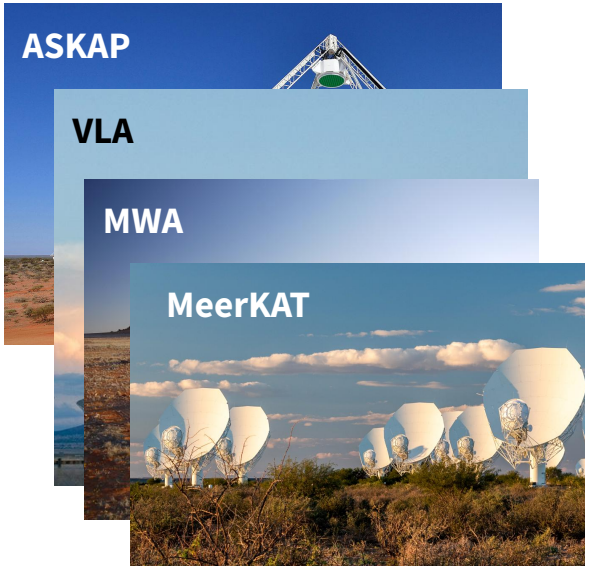
Input parameter distributions

Table 2. Intrinsic population properties varied in the simulations, and reasonable options for ranges to probe.

Property	Options
P	Log-uniform between 60 s – 10^5 s
$L_{\rm radio}$	Single value, 10^{28} erg s^{-1}; Log distribution with index –1
Spectrum	Identical to GPM J1839-10; Uniform within range $-3 < \alpha < -1$
Pulse occupancy	Identical $\eta = 5$ % for all sources; Identical $W = 30$ s for all sources; A uniform distribution of η across 0.2–40 %; A uniform distribution of W across 20–400 s
Spatial distribution	Lorimer+2006 Follow the number density of electrons, e.g. NE2001
Activity window	uniform between two months and ten years identical at 2 months for all sources identical at ten years for all sources
Duty cycle	uniform between 5 and 100 % identical at 5 % for all sources identical at 100 % for all sources

+

Surveys and archives



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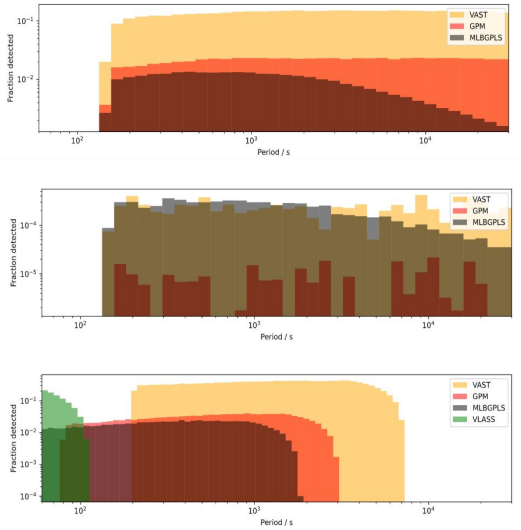
Predicted detection rates



Hurley-Walker et al. in prep: Detection Prospects for Long-Period Radio Transients

Toy modelling

Input parameter distributions

Surveys and archives

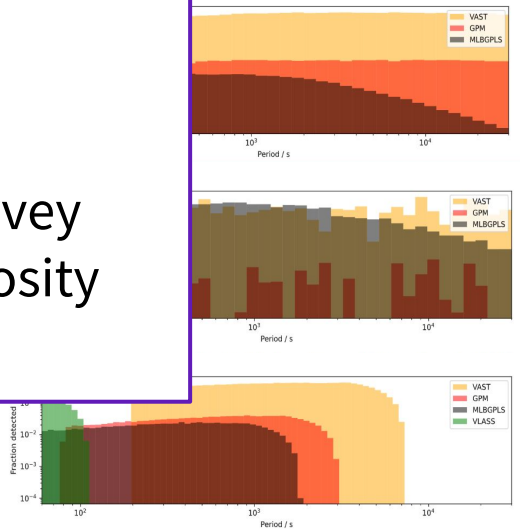
Predicted detection rates

Table 2. Intrinsic population properties varied in the sin
sonable options for ranges to probe.

Property	Options
P	Log-uniform between
$L_{\rm radio}$	Single value, 10^{28}
	Log distribution with
Spectrum	Identical to GPM J1
	Uniform within range
Pulse occupancy	Identical $\eta = 5\,\%$ for a
	Identical $W = 30$ s for
	A uniform distribution of η
	A uniform distribution of W
Spatial distribution	Lorimer+200
	Follow the number density of el
Activity window	uniform between two mont
	identical at 2 months fo
	identical at ten years for all sources
Duty cycle	uniform between 5 and 100 %
	identical at 5 % for all sources
	identical at 100 % for all sources

Super preliminary predictions:

- MWA to find O(10) in the archive
- VAST to find O(10) per year
- MeerKAT L-band Galactic Plane Survey equally productive for some luminosity distributions



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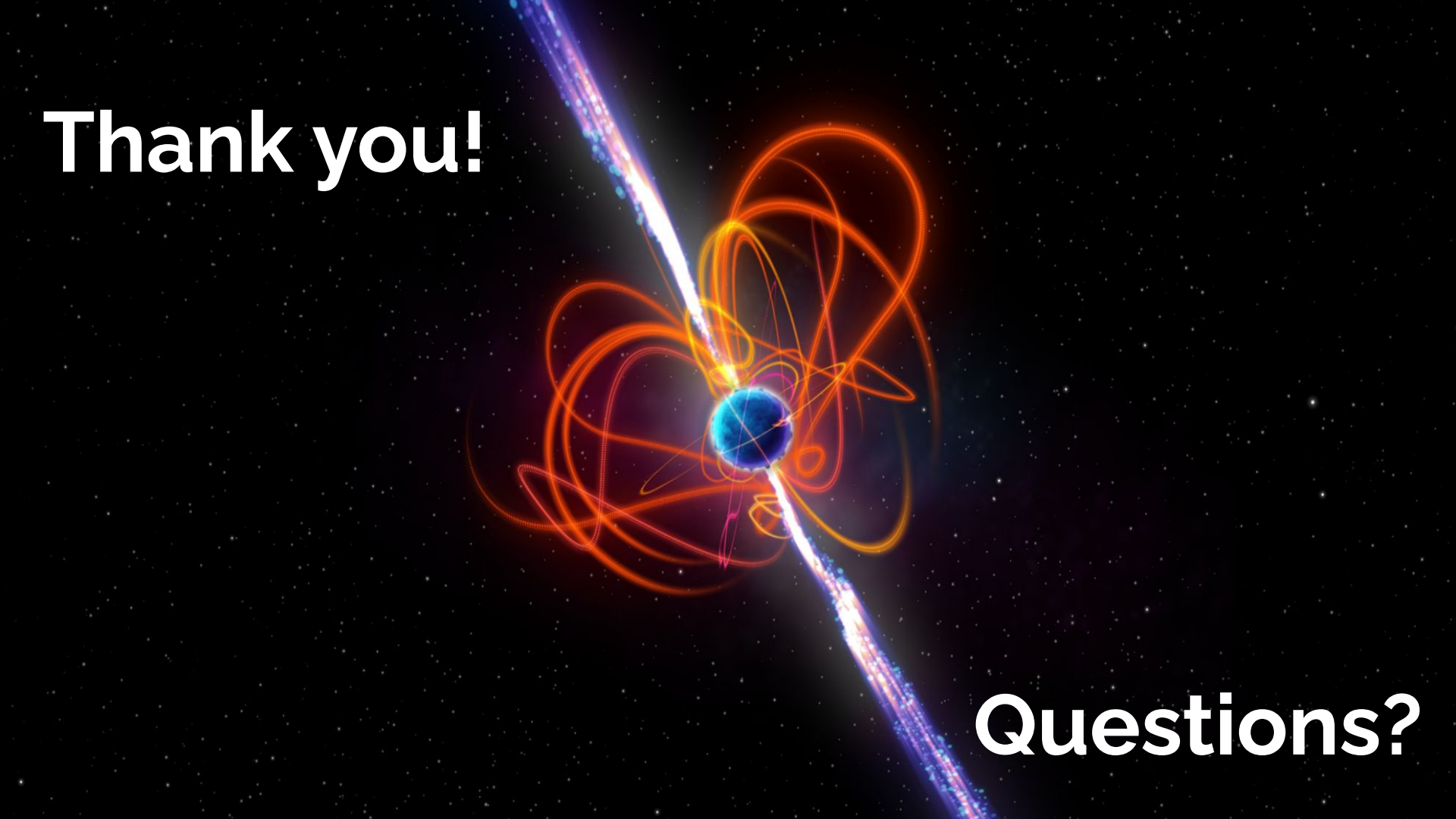
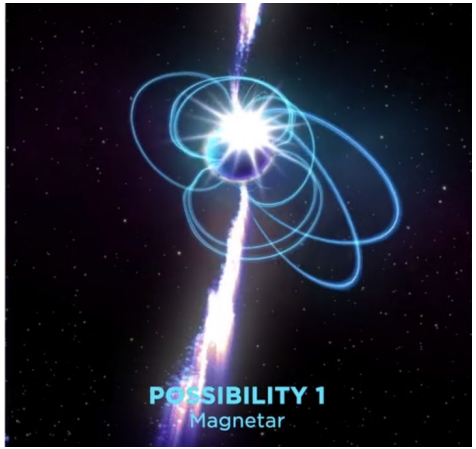
Thank you!



Questions?

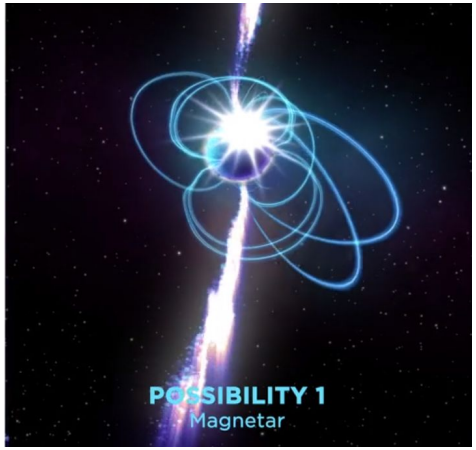
What are they?

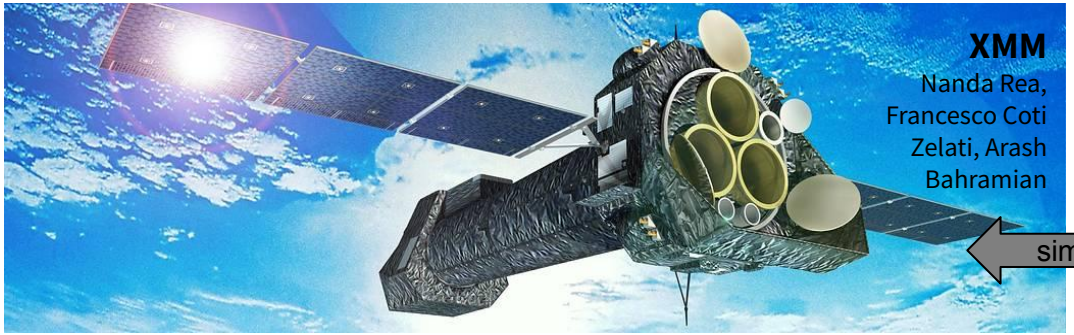


Magnetars typically go into outburst to produce radio emission…

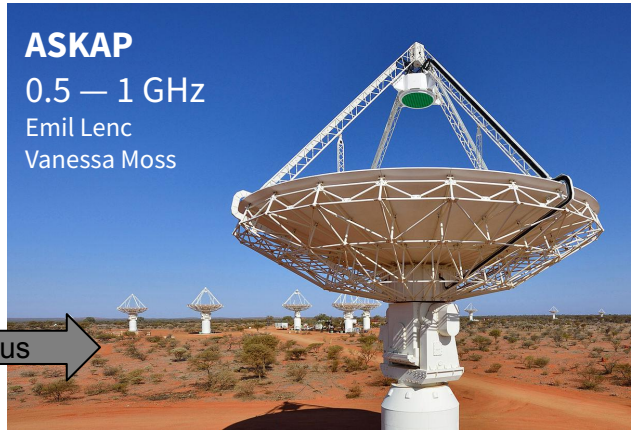
Multiwavelength follow-up

Magnetars typically go into outburst to produce radio emission…

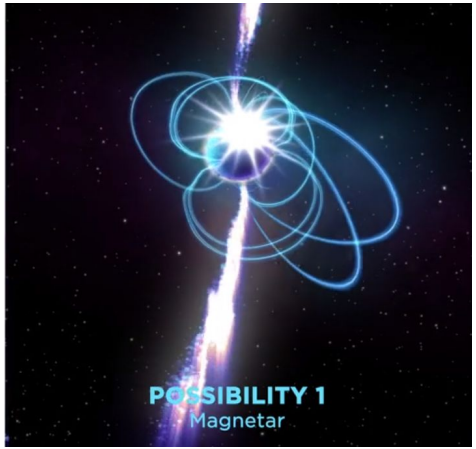




simultaneous



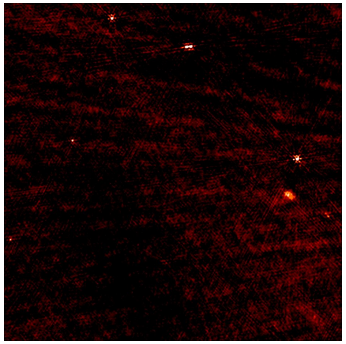
Multiwavelength follow-up



Magnetars typically go into outburst to produce radio emission…

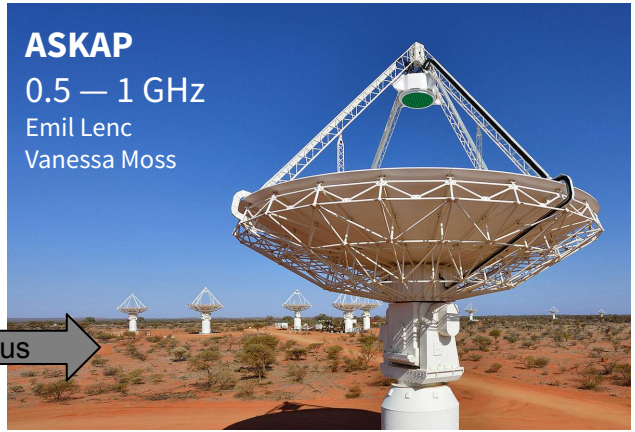
$L_x < 10^{33}$ erg/s

Orders of magnitude lower than expected from magnetar outbursts!



Credit:
Emil Lenc

simultaneous



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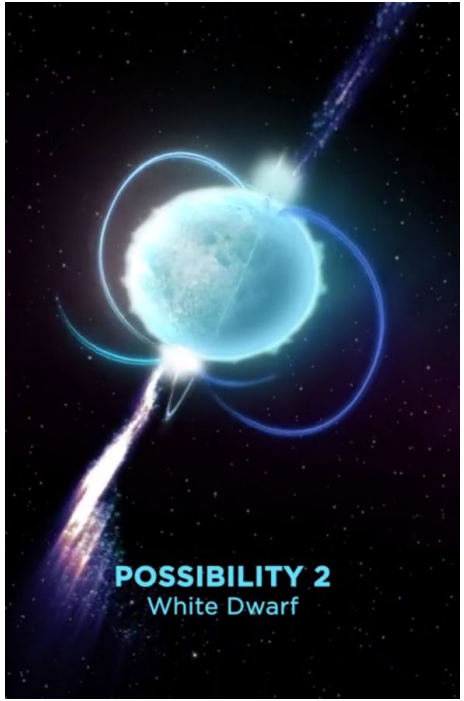

White dwarf high moment of inertia I could explain spin-down luminosity

$$L_{\text{spin}} = \frac{4\pi^2 I \dot{P}}{P^3}$$

A white dwarf pulsar?

A 5.3-minute-period pulsing white dwarf in a binary detected from radio to X-rays

Ingrid Pelisoli[1*], T. R. Marsh[1], David A. H. Buckley[2,3,4], I. Heywood[5,6,7], Stephen. B. Potter[2,8], Axel Schwope[9], Jaco Brink[2,3], Annie Standke[9,10], P. A. Woudt[3], S. G. Parsons[11], M. J. Green[12], S. O. Kepler[13], James Munday[1,14], A. D. Romero[13], E. Breedt[15], A. J. Brown[11], V. S. Dhillon[11,16], M. J. Dyer[11], P. Kerry[11], S. P. Littlefair[11], D. I. Sahman[11], and J. F. Wild[11]

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[7]South African Radio Astronomy Observatory, 2 Fir Street, Observatory 7925, South Africa
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[12]School of Physics and Astronomy, Tel-Aviv University, Tel-Aviv 6997801, Israel
[13]Instituto de Física, Universidade Federal do Rio Grande do Sul, 91501-970 Porto Alegre, RS, Brazil
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[15]Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK
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*ingrid.pelisoli@warwick.ac.uk

White dwarf stars are the most common stellar fossils. When in binaries, they make up the dominant form of compact object binary within the Galaxy and can offer insight into different aspects of binary formation and evolution. One of the most remarkable white dwarf binary systems identified to date is AR Scorpii (henceforth AR Sco). AR Sco is composed of an M-dwarf star and a rapidly-spinning white dwarf in a 3.56-hour orbit. It shows pulsed emission with a period of 1.97 minutes over a broad range of wavelengths, which led to it being known as a white dwarf pulsar. Both the pulse mechanism and the evolutionary origin of AR Sco provide challenges to theoretical models. Here we report the discovery of the first sibling of AR Sco, J191213.72−441045.1 (henceforth J1912−4410), which harbours a white dwarf in a 4.03-hour orbit with an M-dwarf and exhibits pulsed emission with a period of 5.30 minutes. This discovery establishes binary white dwarf pulsars as a class and provides support for proposed formation models for white dwarf pulsars.

- L-band peak flux density ~4mJy
- Spectral index ~ -3
- → 154-MHz flux density ~ 3Jy
- Distance = 119 pc
- → Luminosity ~ 1000x lower than GPMJ1839-10 or GLEAM-XJ1627

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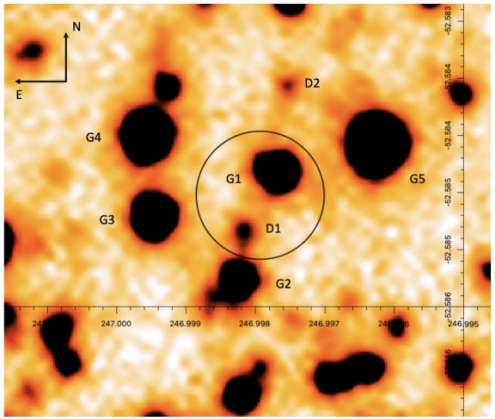
- Binarity required by current models



Binary WD&main sequence star excluded for GLEAM-X J1627 by deep optical IR observations

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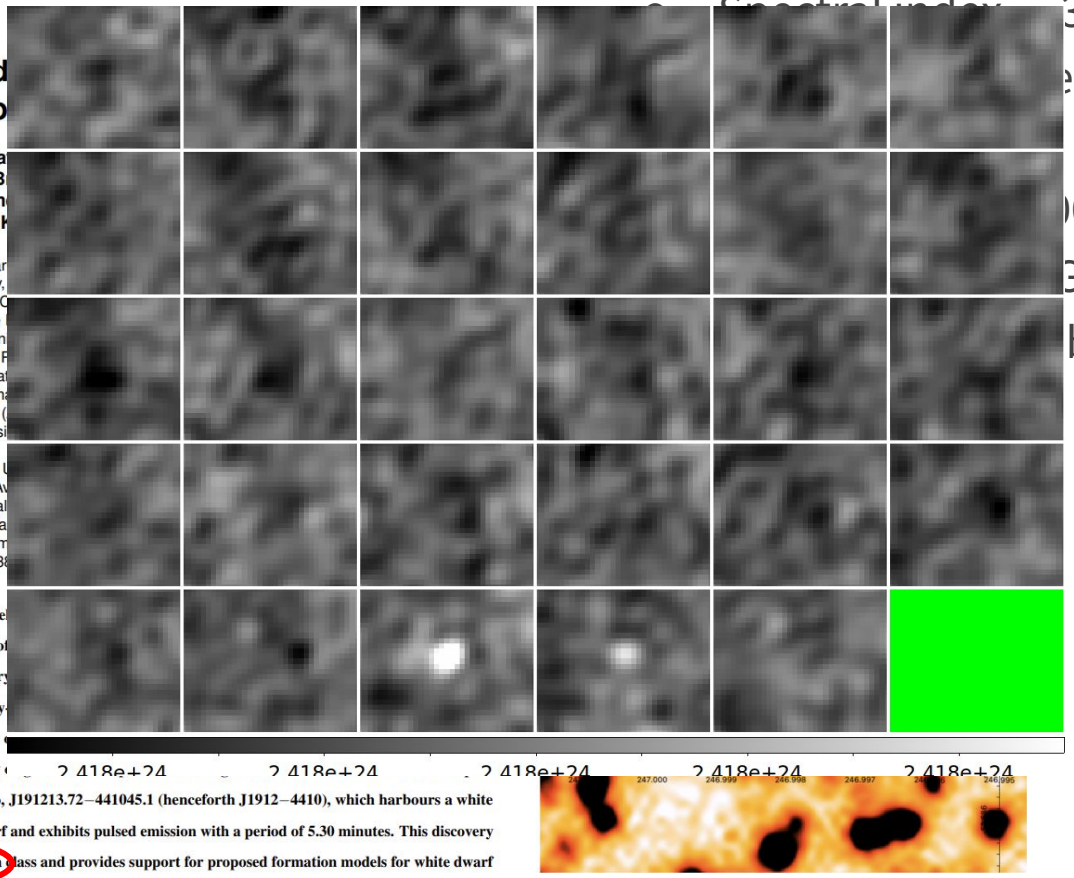

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A 5.3-minute-period detected from radio

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