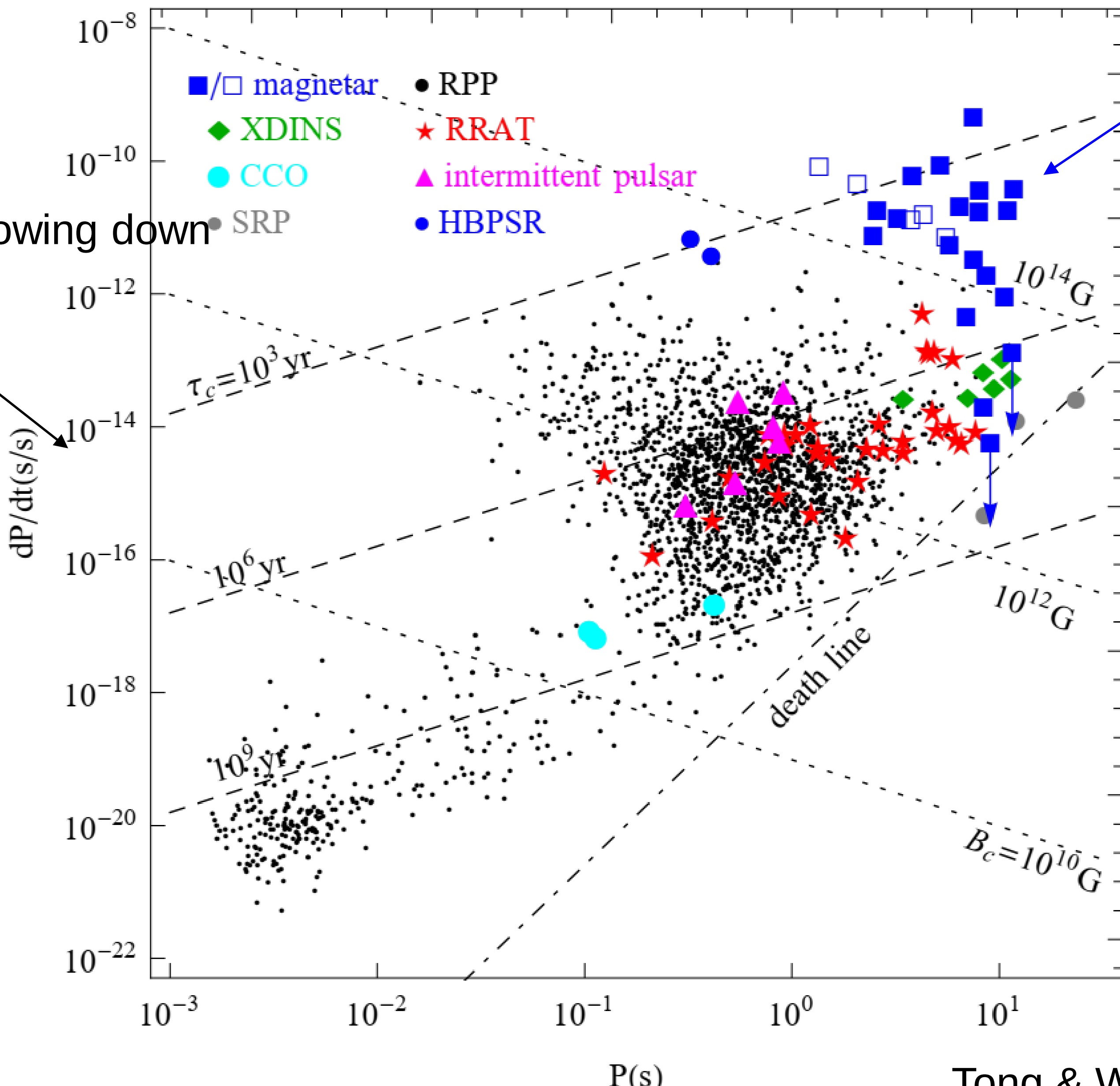
磁星和长周期脉冲星
Magnetars and long period radio pulsars

仝号
广州大学

tonghao@gzhu.edu.cn

Pulsars are slowing down

Magnetars



Tong & Wang (2014)

第一个背景

Young et al. 1999

8.5s

letters to nature

A radio pulsar with an 8.5-second period that challenges emission models

M. D. Young*, R. N. Manchester† & S. Johnston‡

* *Department of Physics, University of Western Australia, Nedlands, WA 6907, Australia*

† *Australia Telescope National Facility, CSIRO, PO Box 76, Epping, NSW 2121, Australia*

‡ *Research Centre for Theoretical Astrophysics, University of Sydney, NSW 2006, Australia*

Radio pulsars are rotating neutron stars that emit beams of radio waves from regions above their magnetic poles. Popular theories[1–4] of the emission mechanism require continuous electron–positron pair production, with the potential responsible for accelerating the particles being inversely related to the spin period. Pair production will stop when the potential drops below a threshold, so the models predict that radio emission will cease when the period exceeds a value that depends on the magnetic field strength and configuration. Here we show that the pulsar J2144–3933, previously thought to have a period of 2.84 s, actually has a period of 8.51 s, which is by far the longest of any

Young et al. 1999

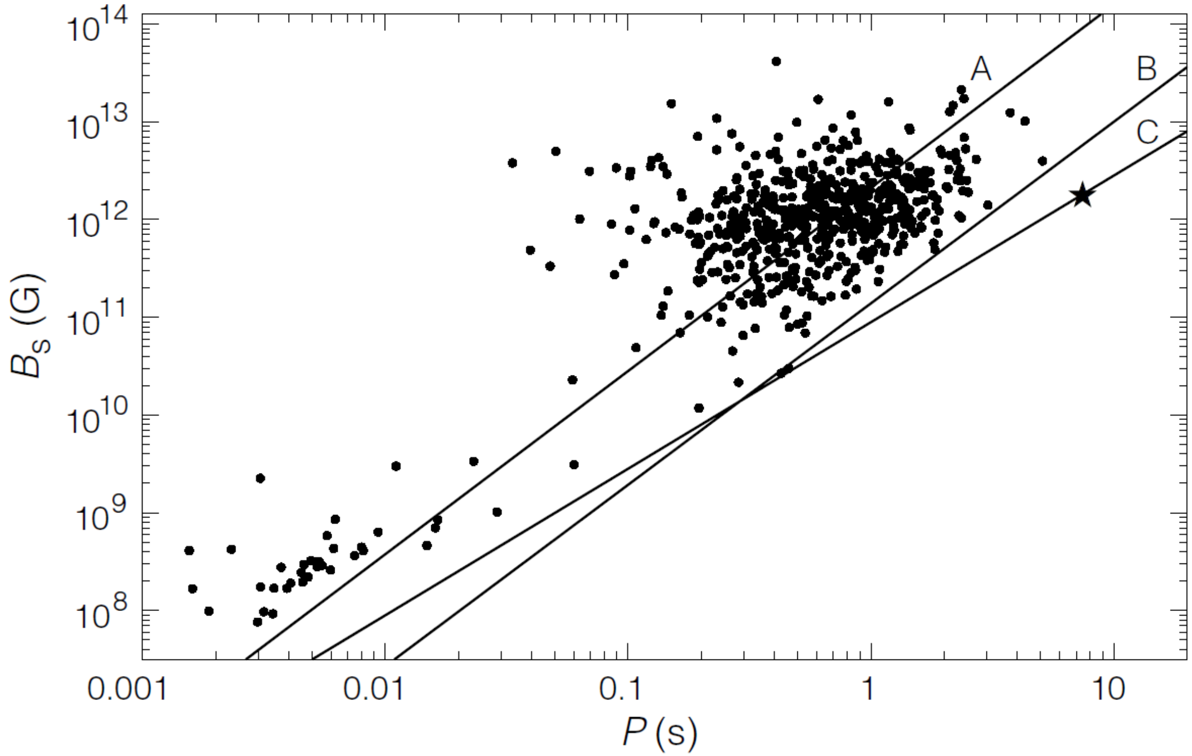


Figure 2 Distribution of known pulsars (excluding globular cluster pulsars) on the P-B_s plane, where P is the pulsar period and B_s is the surface magnetic dipole field strength. PSR J2144–3933 is marked with a filled star symbol. The sloping lines are 'death lines' according to various assumptions regarding field-line curvature in the emission region (see text). Line A, $4 \log B_s - 7.5 \log P = 49.3$; line B, $7 \log B_s - 13 \log P = 78$; line C, $4 \log B_s - 6 \log P = 43.8$.

Tan et al. 2018: **23.5s**

THE ASTROPHYSICAL JOURNAL, 866:54 (12pp), 2018 October 10 https://doi.org/10.3847/1538-4357/aade88

CrossMark

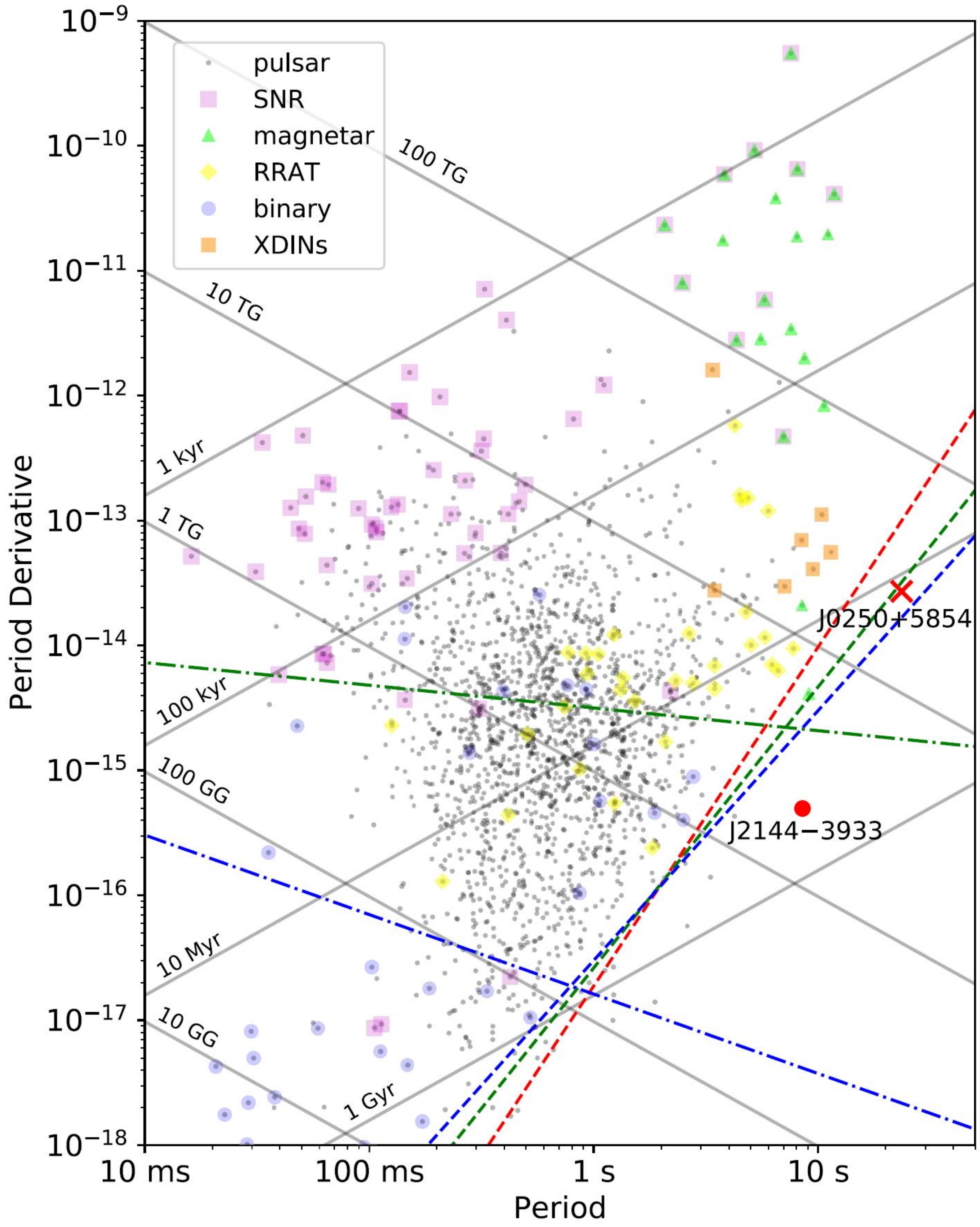
LOFAR Discovery of a 23.5 s Radio Pulsar

C. M. Tan[1], C. G. Bassa[2], S. Cooper[1], T. J. Dijkema[2], P. Esposito[3,4], J. W. T. Hessels[2,3], V. I. Kondratiev[2,5], M. Kramer[1,6], D. Michilli[2,3], S. Sanidas[1], T. W. Shimwell[2], B. W. Stappers[1], J. van Leeuwen[2,3], I. Cognard[7,8], J.-M. Grießmeier[7,8], A. Karastergiou[9,10,11], E. F. Keane[12], C. Sobey[13,14], and P. Weltevrede[1]
[1] Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, Manchester M13 9PL, UK
chiamin.tan@postgrad.manchester.ac.uk
[2] ASTRON, the Netherlands Institute for Radio Astronomy, Postbus 2, NL-7990 AA Dwingeloo, The Netherlands
[3] Anton Pannekoek Institute for Astronomy, University of Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands
[4] INAF—Istituto di Astrofisica Spaziale e Fisica Cosmica—Milano, via E. Bassini 15, I-20133 Milano, Italy
[5] Astro Space Centre, Lebedev Physical Institute, Russian Academy of Sciences, Profsoyuznaya Str. 84/32, Moscow 117997, Russia
[6] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
[7] Laboratoire de Physique et Chimie de l'Environnement et de l'Espace, Université d'Orléans/CNRS, F-45071 Orléans Cedex 02, France
[8] Station de Radioastronomie de Nançay, Observatoire de Paris, CNRS/INSU, F-18330 Nançay, France
[9] Oxford Astrophysics, Denys Wilkinson Building, Keble Road, Oxford OX1 3RH, UK
[10] Department of Physics and Astronomy, University of the Western Cape, Private Bag X17, Bellville 7535, South Africa
[11] Department of Physics and Electronics, Rhodes University, P.O. Box 94, Grahamstown 6140, South Africa
[12] SKA Organisation, Jodrell Bank Observatory, SK11 9DL, UK
[13] International Centre for Radio Astronomy Research—Curtin University, GPO Box U1987, Perth, WA 6845, Australia
[14] CSIRO Astronomy and Space Science, P.O. Box 1130, Bentley WA 6102, Australia
Received 2018 July 24; revised 2018 August 29; accepted 2018 August 31; published 2018 October 11

Abstract

We present the discovery of PSR J0250+5854, a radio pulsar with a spin period of 23.5 s. This is the slowest-spinning radio pulsar known. PSR J0250+5854 was discovered by the LOFAR Tied-Array All-Sky Survey

Tan et al. 2018



Our work:

THE ASTROPHYSICAL JOURNAL, 876:131 (6pp), 2019 May 10
https://doi.org/10.3847/1538-4357/ab17da

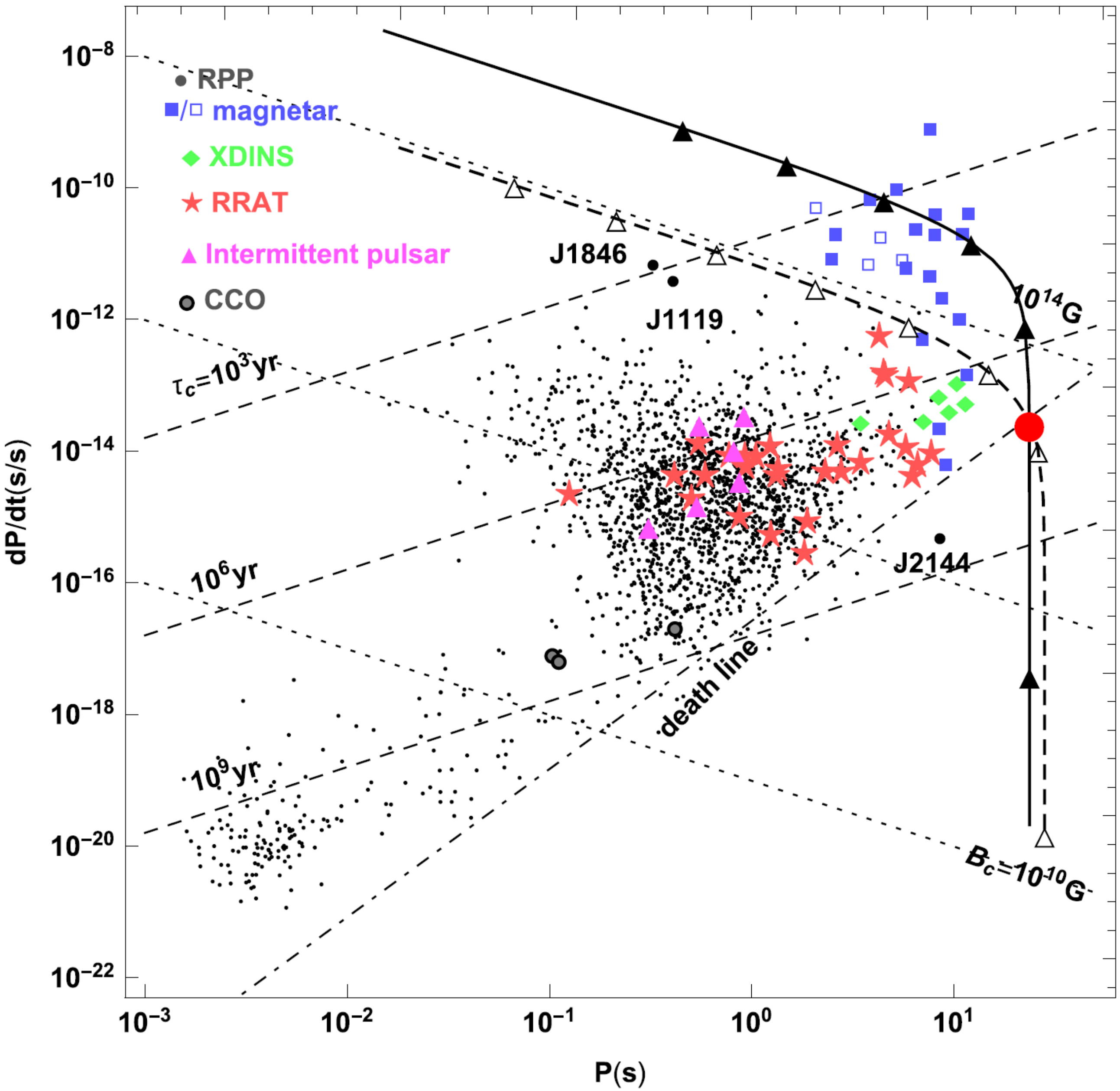
CrossMark

Rotational Evolution of the Slowest Radio Pulsar, PSR J0250+5854

F. F. Kou[1,2], H. Tong[3], R. X. Xu[4,5], and X. Zhou[2,6]
[1] CAS Key Laboratory of FAST, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, People's Republic of China
[2] Xinjiang Astronomical Observatories, Chinese Academy of Sciences, Urumqi 830011, People's Republic of China
[3] School of Physics and Electronic Engineering, Guangzhou University, Guangzhou 510006, People's Republic of China; htong_2005@163.com
[4] School of Physics and State Key Laboratory of Nuclear Physics and Technology, Peking University, Beijing 100871, People's Republic of China
[5] Kavil Institute for Astronomy and Astrophysics, Peking University, Beijing 100871, People's Republic of China
[6] Key Laboratory of Radio Astronomy, Chinese Academy of Sciences, Beijing, People's Republic of China
Received 2019 January 2; revised 2019 March 21; accepted 2019 April 8; published 2019 May 13

Abstract

We apply theoretical spin-down models of magnetospheric evolution and magnetic field decay to simulate the possible evolution of PSR J0250+5854, which is the slowest-spinning radio pulsar detected to date. Considering the alignment of inclination angle in a 3D magnetosphere, it is possible that PSR J0250+5854 has a high magnetic field comparable with magnetars or/and high magnetic field pulsars, if a small inclination angle is considered. Our calculations show that similar long-period pulsars tend to have a relatively low period derivative in this case. In another case of magnetic field decay, calculations also show a possible connection between PSR J0250+5854 and high dipole-magnetic field magnetars. The evolutionary path indicates a relatively high spin-down rate for similar long-period pulsars.



RPP
magnetar
XDINS
RRAT
Intermittent pulsar
CCO
J1846
J1119
J2144
10^{14}G
$\tau_c=10^3$yr
10^6yr
10^9yr
death line
$B_c=10^{10}$G
dP/dt(s/s)
P(s)

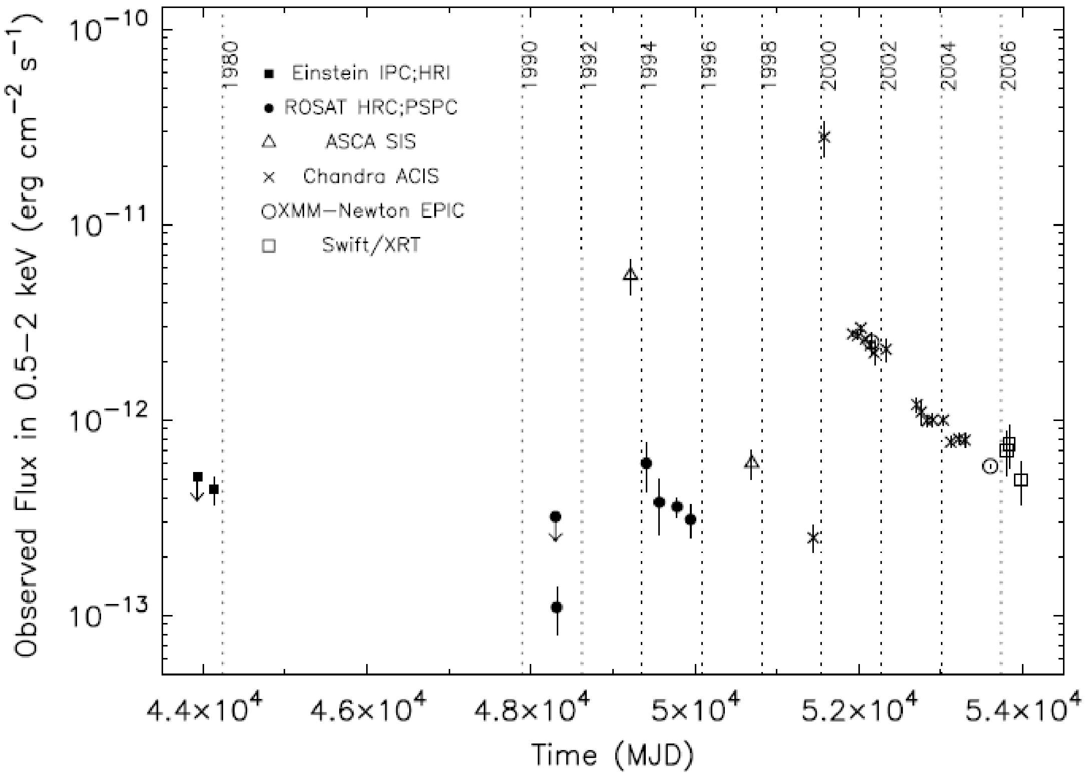
第二个背景

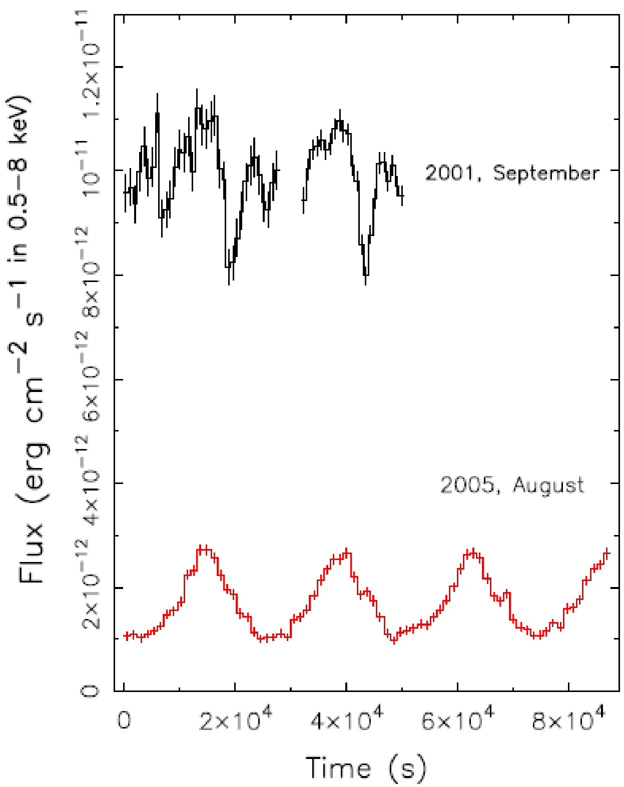
CCO in RCW 103

- Garmire et al. (2000), IAUC 7350
- period~ 6.3 hr
- may be a low mass X-ray binary in a supernova remnant

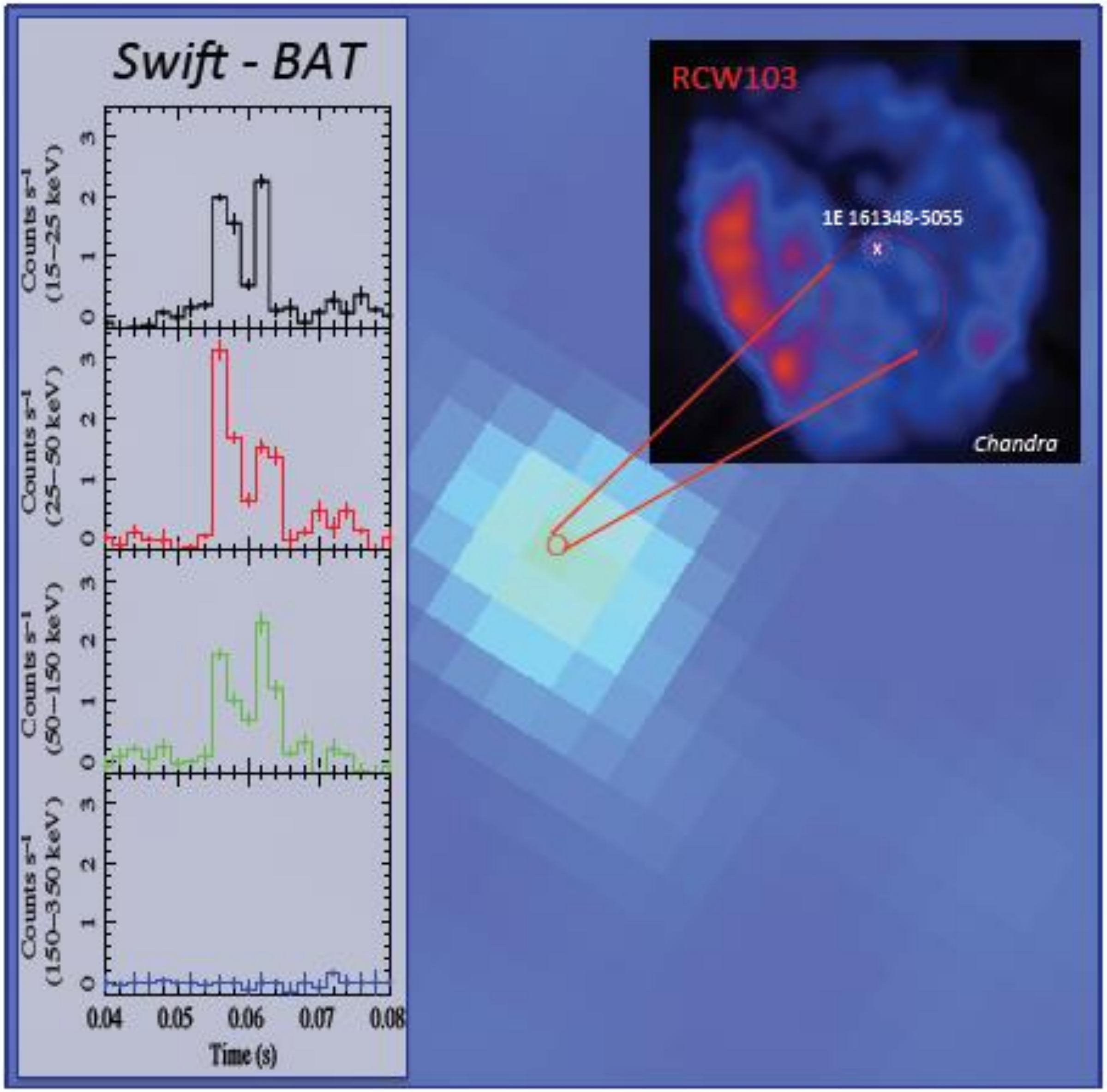
CCO (1E 1613) in RCW 103

(De Luca+ 2006)

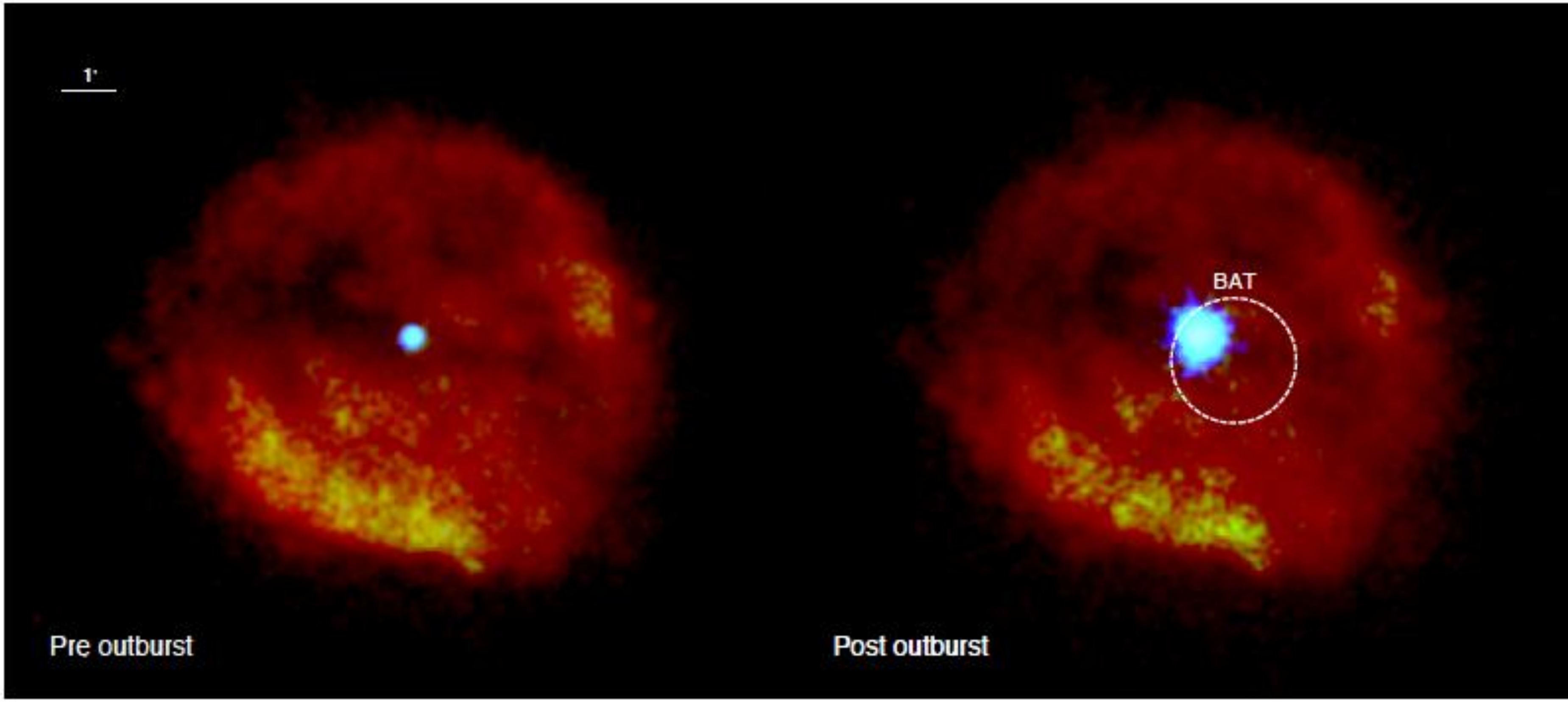




Burst from the RCW 103 direction, Rea et al. 2016



Outburst from the CCO in RCW 103, D’Ai et al. 2016



Nature of CCO in RCW 103

1. a magnetar!
2. a very special magnetar compared with magnetars, CCOs, normal neutron stars and accreting neutron stars: the longest spin period (6.6 hours) (at that time)!
3. a magnetar braked down by a fallback disk in the past?

$$\dot{M}_{\rm acc} = \dot{M}_{\rm Edd}, \qquad 0 < t < t_{\rm eq},$$
$$= \dot{M}_{\rm Edd}\left(\frac{t}{t_{\rm eq}}\right)^{-\alpha}, \quad t \geqslant t_{\rm eq}.$$

3 weeks later (Aug 6th):

Astrophysics > High Energy Astrophysical Phenomena

Rotational evolution of magnetars in the presence of a fallback disk

H. Tong, W. Wang, X. W. Liu, R. X. Xu

(Submitted on 6 Aug 2016)

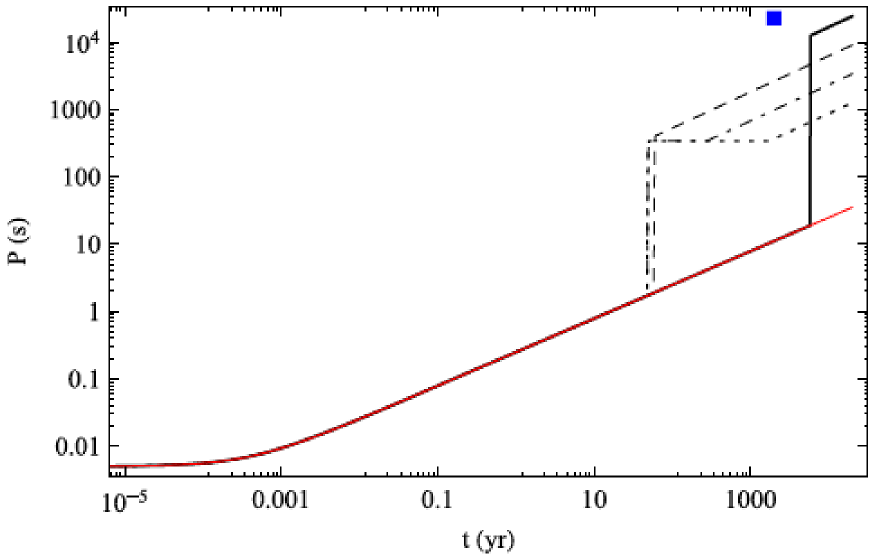
Magnetars may have strong surface dipole field. Observationally, two magnetars may have passive fallback disks. In the presence of a fallback disk, the rotational evolution of magnetars may be changed. In the self-similar fallback disk model, it is found that: (1) When the disk mass is significantly smaller than $10^{-6}\ M_{\odot}$, the magnetar is unaffected by the fallback disk and it will be a normal magnetar. (2) When the disk mass is large, but the magnetar's surface dipole field is 10^{14} G, the magnetar will also be a normal magnetar. A magnetar plus a passive fallback disk system is expected. This may correspond to the observations of magnetars 4U 0142+61, and 1E 2259 +586. (3) When the disk mass is large, and the magnetar's surface dipole field is as high as 4×10^{15} G, the magnetar will evolve from the ejector phase to the propeller phase, and then enter into rotational equilibrium. The magnetar will be slowed down quickly in the propeller phase. The final rotational period can be as high 2×10^{4} s. This may correspond to the super-slow magnetar in the supernova remnant RCW 103. Therefore, the three kinds of magnetars can be understood uniformly.

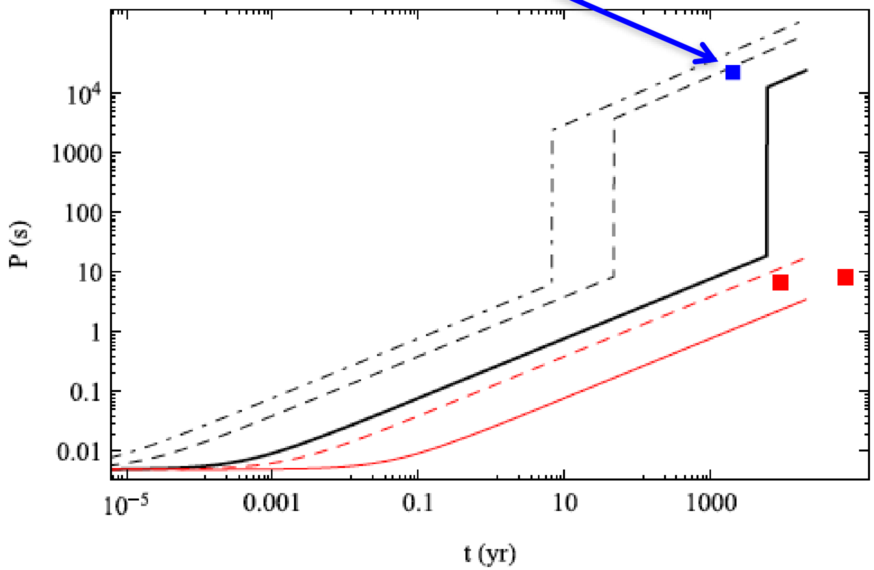
Comments: 12 pages, 4 figures, submitted

Rotational evolution of magnetars in the presence of a fallback disk:
for different masses of the disk (left) and different magnetic field of the magnetar (right)

Only for **a high disk mass** (10^-5 Msun) and **high dipole field** (5*10^15 G), the magnetar will be spun down significantly by the fallback disk

Tong et al. 2016





正题：长周期脉冲星

Hurley-Walker et al. 2022: 1091s

Article

A radio transient with unusually slow periodic emission

https://doi.org/10.1038/s41586-021-04272-x

Received: 30 July 2021

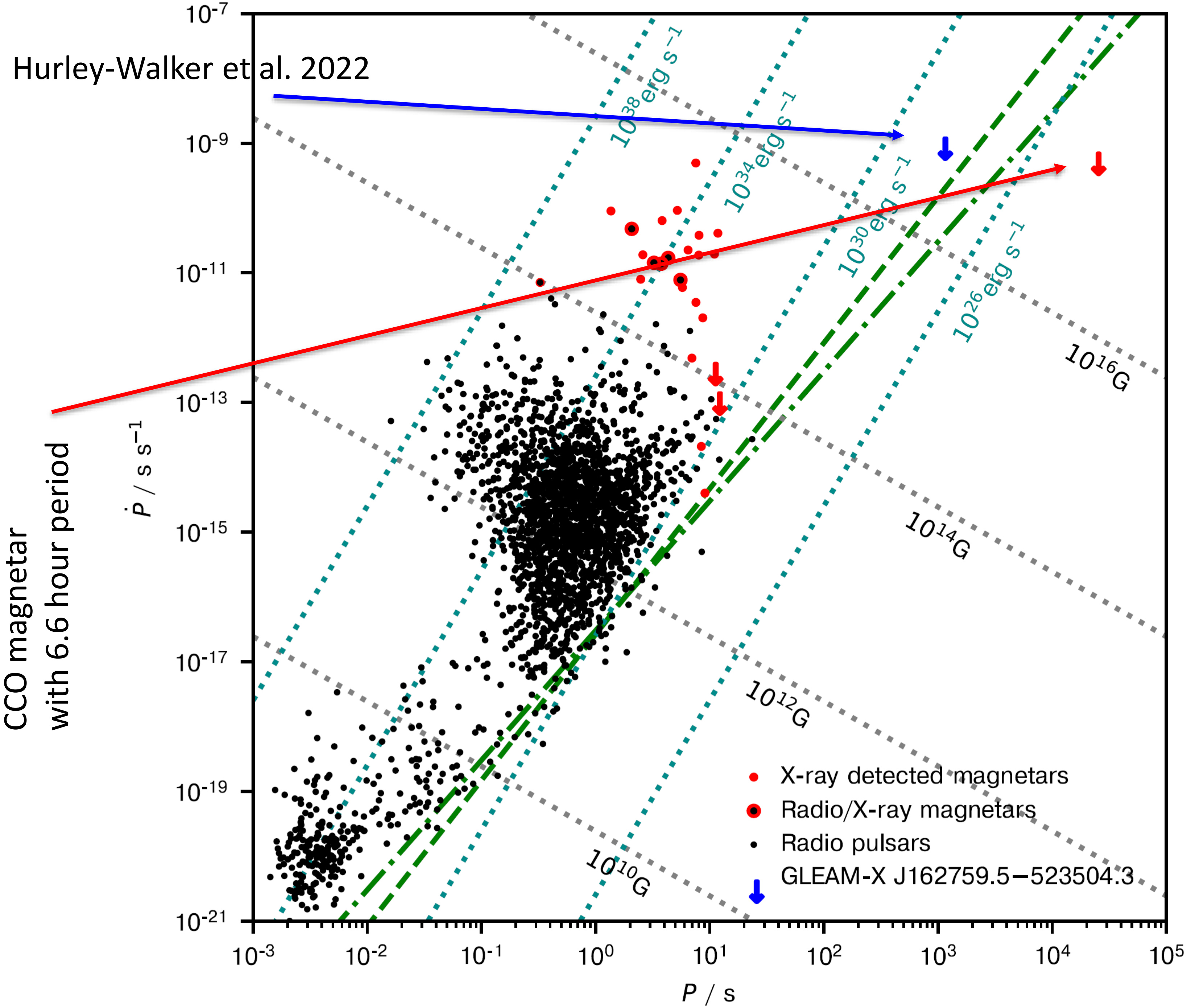
Accepted: 19 November 2021

Published online: 26 January 2022

Check for updates

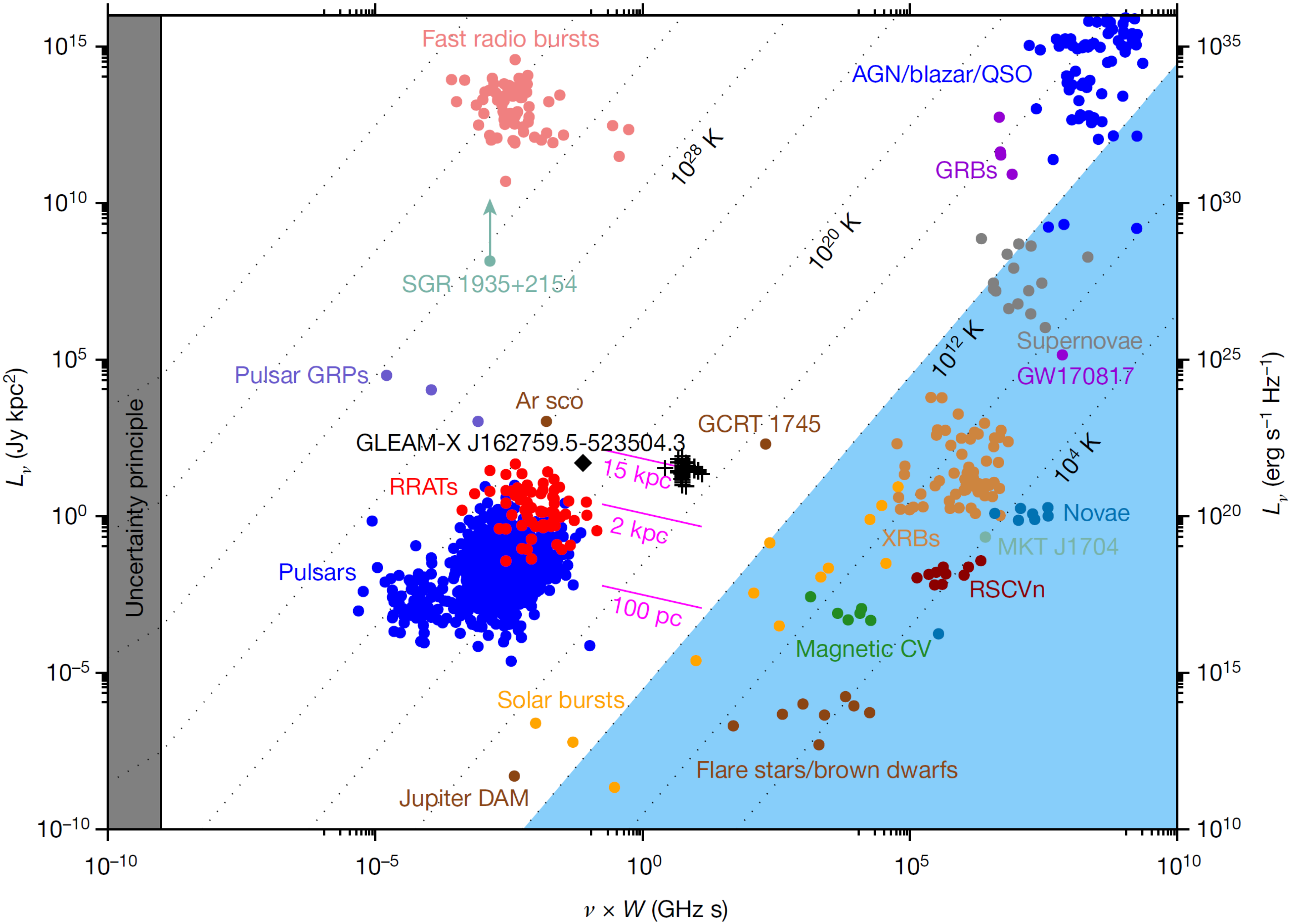
N. Hurley-Walker[1]✉, X. Zhang[2,3], A. Bahramian[1], S. J. McSweeney[1], T. N. O'Doherty[1], P. J. Hancock[1], J. S. Morgan[1], G. E. Anderson[1], G. H. Heald[2] & T. J. Galvin[1]

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 emission from flaring M dwarfs[1], stellar magnetospheric plasma interactions with exoplanets[2] and a population of steep-spectrum pulsars[3], making Galactic-plane searches a prospect for blind-transient discovery. Here we report an analysis of archival low-frequency radio data that reveals a periodic, low-frequency radio transient. We find that the source pulses every 18.18 min, an unusual periodicity that has, to our knowledge, not been observed previously. The emission is highly linearly polarized, bright, persists for 30–60 s on each occurrence and is visible across a broad frequency range. At times, the pulses comprise short-duration (<0.5 s) bursts; at



Hurley-Walker et al. 2022
CCO magnetar
with 6.6 hour period
10^{38} erg s^{-1}
10^{34} erg s^{-1}
10^{30} erg s^{-1}
10^{26} erg s^{-1}
10^{16}G
10^{14}G
10^{12}G
10^{10}G
X-ray detected magnetars
Radio/X-ray magnetars
Radio pulsars
GLEAM-X J162759.5−523504.3
$\dot{P}$ / s s^{-1}
P / s
10^{-7}
10^{-9}
10^{-11}
10^{-13}
10^{-15}
10^{-17}
10^{-19}
10^{-21}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}

Hurley-Walker et al. 2022



Our work:arXiv:2204.01957

DRAFT VERSION APRIL 6, 2022
Typeset using LATEX **twocolumn** style in AASTeX631

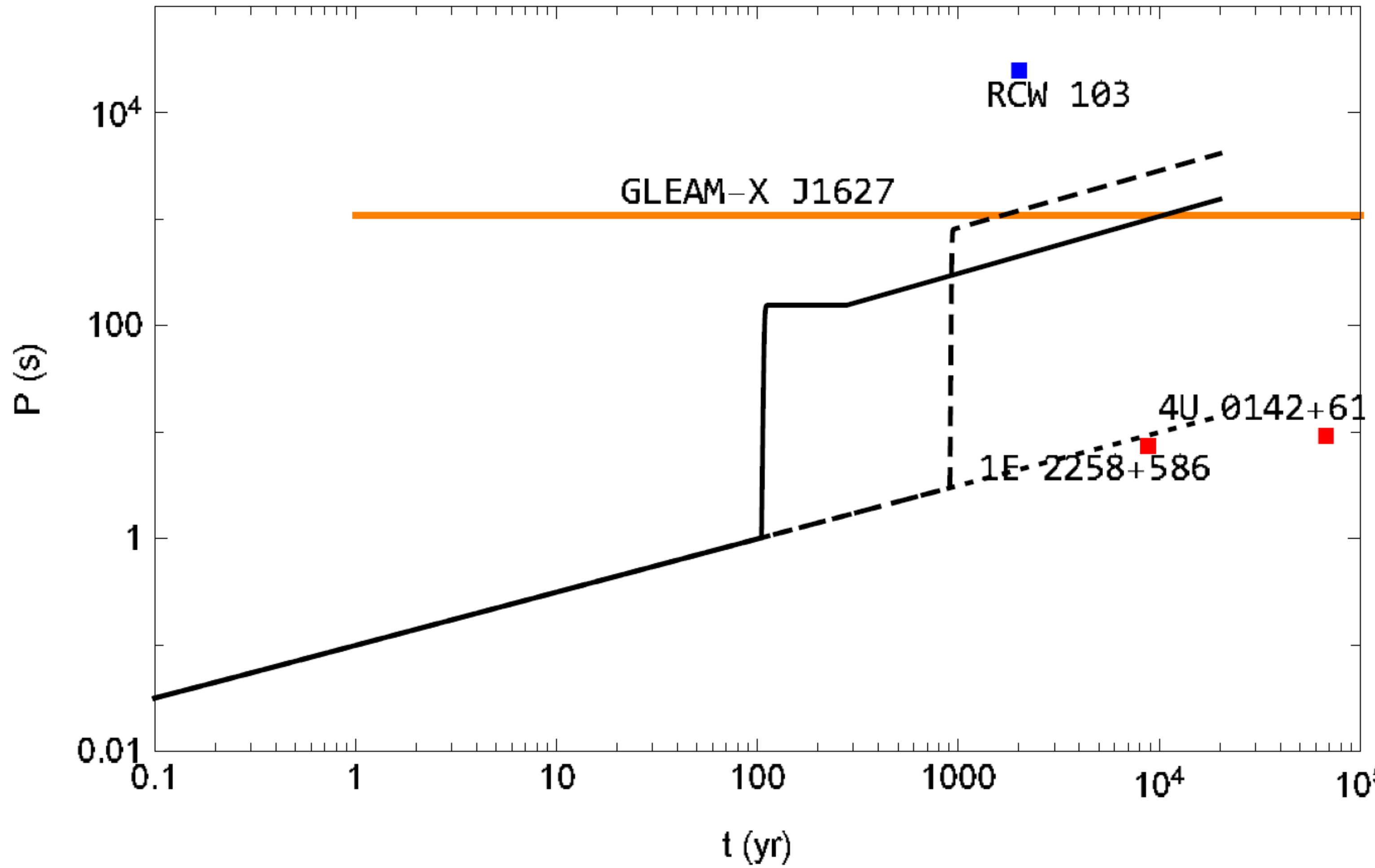
Discussions on the nature of GLEAM-X J162759.5−523504.3

H. TONG[1]

[1] *School of Physics and Materials Science, Guangzhou University, Guangzhou 510006, China*

ABSTRACT

The nature of the long period radio transient GLEAM-X J162759.5−523504.3 (GLEAM-X J1627 for short) is discussed. We try to understand both its radio emission and pulsation in the neutron star scenario. We think that: (1) From the radio emission point of view, GLEAM-X J1627 can be a radio-loud magnetar. (2) From the rotational evolution point of view, GLEAM-X J1627 is unlikely to be an isolated magnetar. (3) The 1091s period is unlikely to be the precession period. (4) GLEAM-X J1627 may be a radio-loud magnetar spun-down by a fallback disk. The pulsar death line is modified due to the presence of a fallback disk. This may explain why GLEAM-X J1627 is still radio active with such a long pulsation period. General constraint on the neutron star magnetic field and initial disk mass are given analytically. Possible ways to discriminate between different modelings are also discussed.



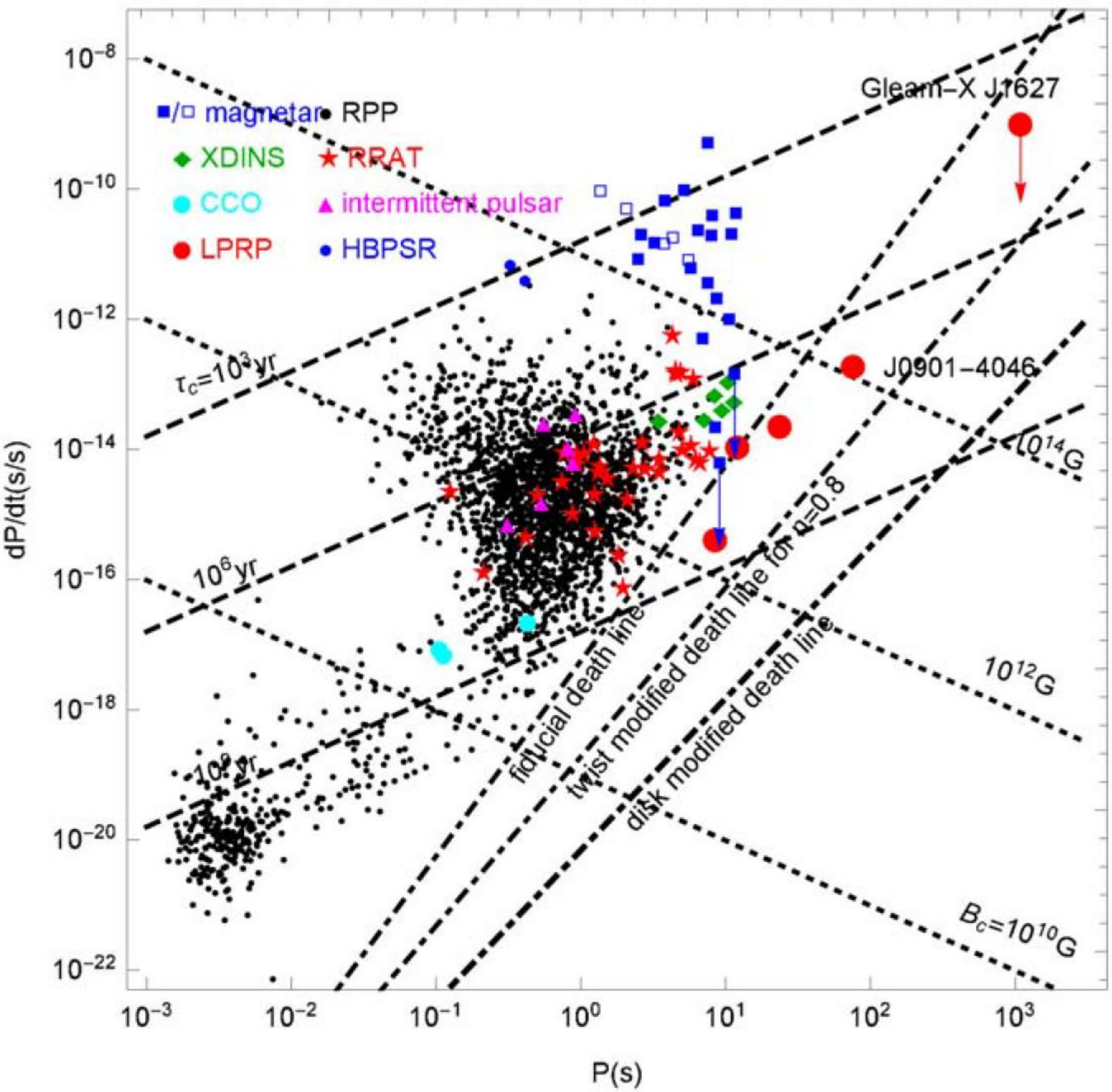
RCW 103
GLEAM-X J1627
4U 0142+61
1E 2258+586
P (s)
t (yr)
10^4
100
1
0.01
0.1
1
10
100
1000
10^4
10^5

2.5. Modification of Pulsar Death Line for Long-period Radio Pulsars

For a large-scale dipole magnetic field, the potential drop across the polar cap with angular extent $\theta_{\rm pc}$ is (Ruderman & Sutherland 1975; Tong 2016)

$$\Phi_{\rm max} = \frac{B_{\rm p} R^2 \Omega}{2c} \sin^2 \theta_{\rm pc}. \qquad (9)$$

A larger polar cap due to
fallback disk or twisted magnetosphere



■/□ magnetar
● RPP
◆ XDINS
★ RRAT
● CCO
▲ intermittent pulsar
● LPRP
● HBPSR
Gleam−X J1627
J0901−4046
τc=10³yr
10⁶yr
10⁹yr
10¹⁴G
10¹²G
Bc=10¹⁰G
fiducial death line
twist modified death line for n=0.8
disk modified death line
dP/dt(s/s)
P(s)
10⁻⁸
10⁻¹⁰
10⁻¹²
10⁻¹⁴
10⁻¹⁶
10⁻¹⁸
10⁻²⁰
10⁻²²
10⁻³
10⁻²
10⁻¹
10⁰
10¹
10²
10³

后续。。。

Transient pulsed radio emission from SGR 1935

Research in Astronomy and Astrophysics, 23:025013 (5pp), 2023 February https://doi.org/10.1088/1674-4527/acae70

A Note on the Anti-glitch of Magnetar SGR 1935+2154

H. Tong
School of Physics and Materials Science, Guangzhou University, Guangzhou 510006, China; tonghao@gzhu.edu.cn
Received 2022 November 3; revised 2022 December 14; accepted 2022 December 19; published 2023 January 20

Abstract

The magnetar SGR 1935+2154 is reported to have an anti-glitch, accompanied by fast radio bursts, and transient pulsed radio emission. In the wind braking model, this triplet event tells people that (1) SGR 1935+2154 does not have a strong particle wind and can be approximated by magnetic dipole braking in the persistent state; (2) its anti-glitch is due to an enhanced particle wind, similar to the first anti-glitch in magnetars; (3) its transient pulsed radio emission may be due to a decreasing emission beam during the outburst; (4) the enhanced particle acceleration potential and pulsar death line may not be the dominate factor.

Caleb et al. 2022: **76s**

nature astronomy

ARTICLES

https://doi.org/10.1038/s41550-022-01688-x

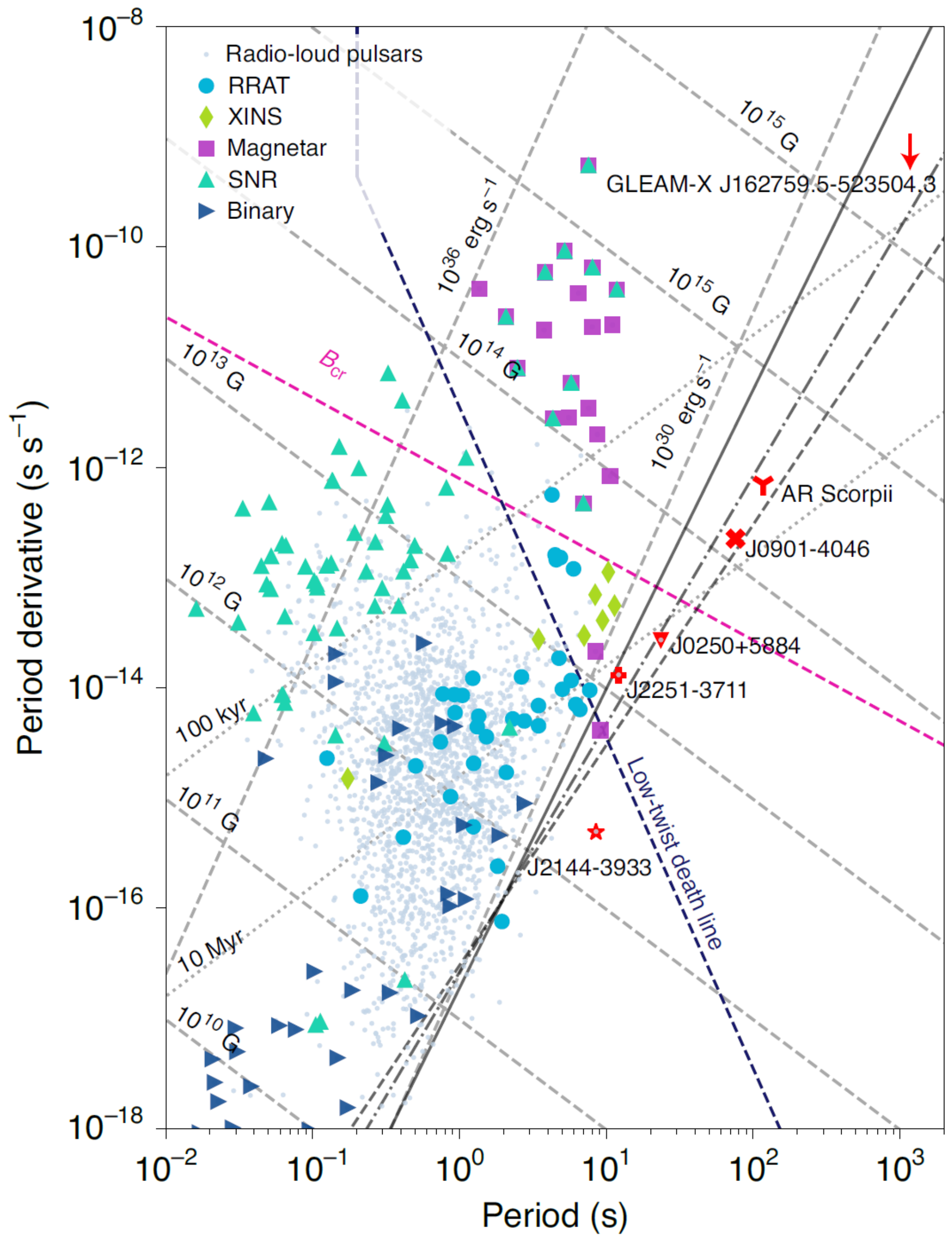
Check for updates

Discovery of a radio-emitting neutron star with an ultra-long spin period of 76 s

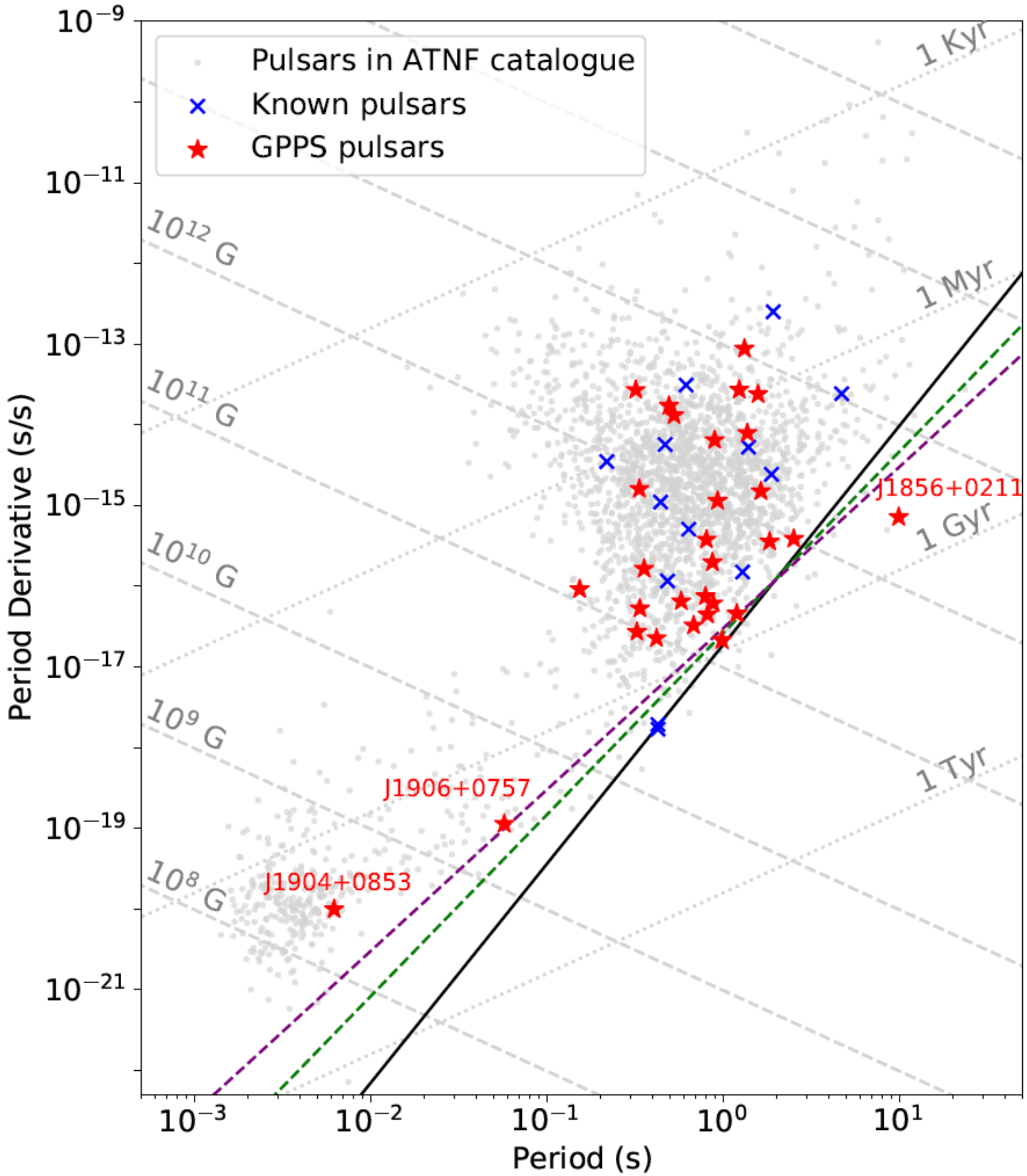
Manisha Caleb[1,2,3,14], Ian Heywood[4,5,6,14], Kaustubh Rajwade[1,7], Mateusz Malenta[1], Benjamin Willem Stappers[1,14], Ewan Barr[8], Weiwei Chen[8], Vincent Morello[1], Sotiris Sanidas[1], Jakob van den Eijnden[4], Michael Kramer[1,8], David Buckley[9,10,11], Jaco Brink[9,10], Sara Elisa Motta[12], Patrick Woudt[10], Patrick Weltevrede[1], Fabian Jankowski[1], Mayuresh Surnis[1], Sarah Buchner[6], Mechiel Christiaan Bezuidenhout[1], Laura Nicole Driessen[1,13] and Rob Fender[4]

The radio-emitting neutron star population encompasses objects with spin periods ranging from milliseconds to tens of seconds. As they age and spin more slowly, their radio emission is expected to cease. We present the discovery of an ultra-long-period radio-emitting neutron star, PSR J0901-4046, with spin properties distinct from the known spin- and magnetic-decay-powered neutron stars. With a spin period of 75.88 s, a characteristic age of 5.3 Myr and a narrow pulse duty cycle, it is uncertain how

Caleb et al. 2022



Su et al. 2023
FAST GPPS IV



磁星和长周期脉冲星
未来展望

1. Evolution under strong B & fallback disk
2. Pulsar death line under fallback disk and multipole field
3. Difference between white dwarf pulsars and neutron star pulsars
4. Rotational and inclination evolution of long period pulsars and magnetars
5. Transient pulsed radio emission?
6. …