A freely precessing magnetar following an X-ray outburst

Gregory Desvignes et al.

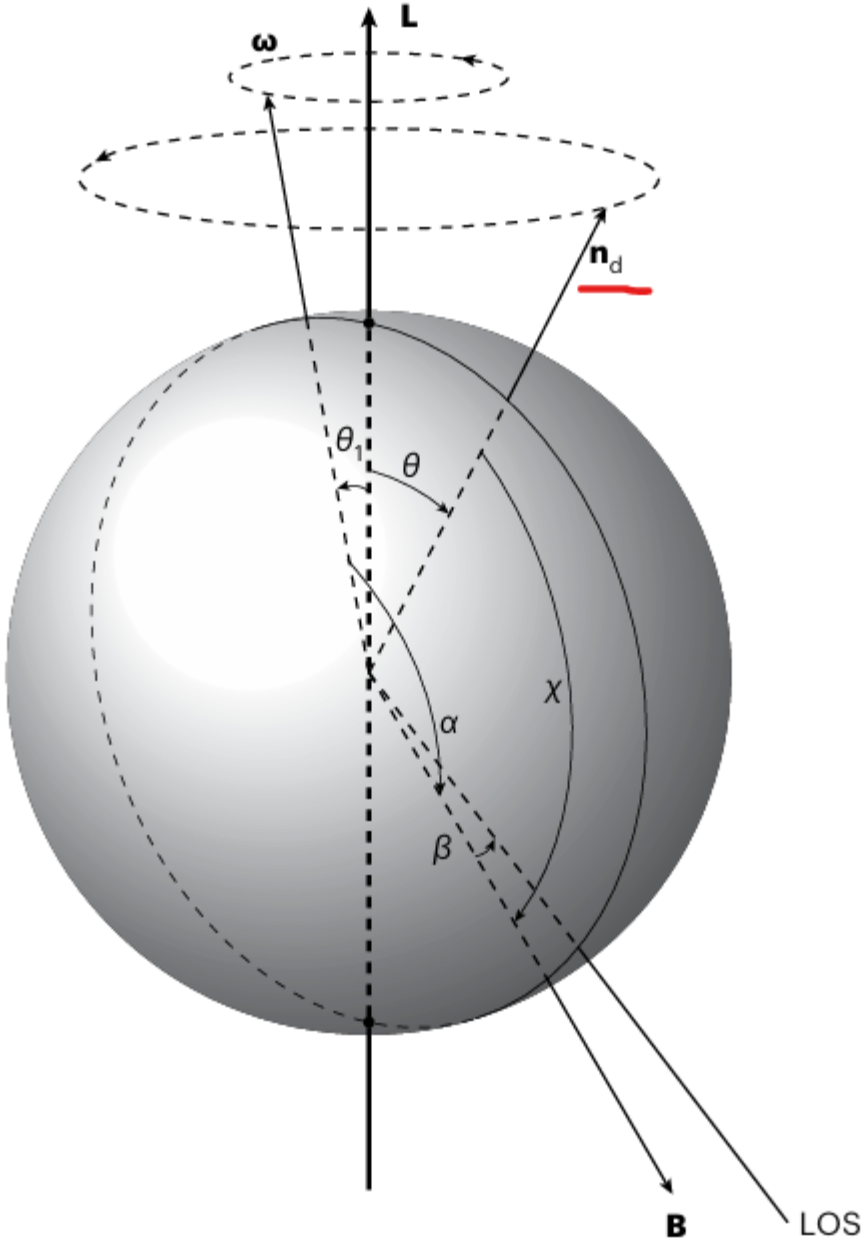
https://doi.org/10.1038/s41550-024-02226-7

Speaker: 金奕澄

Precession of Magnetars

- Force Precession
- Cause: e.g. Lense-Thirring effect
- α remains fixed with time,
- β is modulated by the relativistic spin-precession period as predicted by GR

- Free Precession
- Cause: the aspherical deformation of the NS (expressed as its ellipticity ϵ)
- Variable α and β



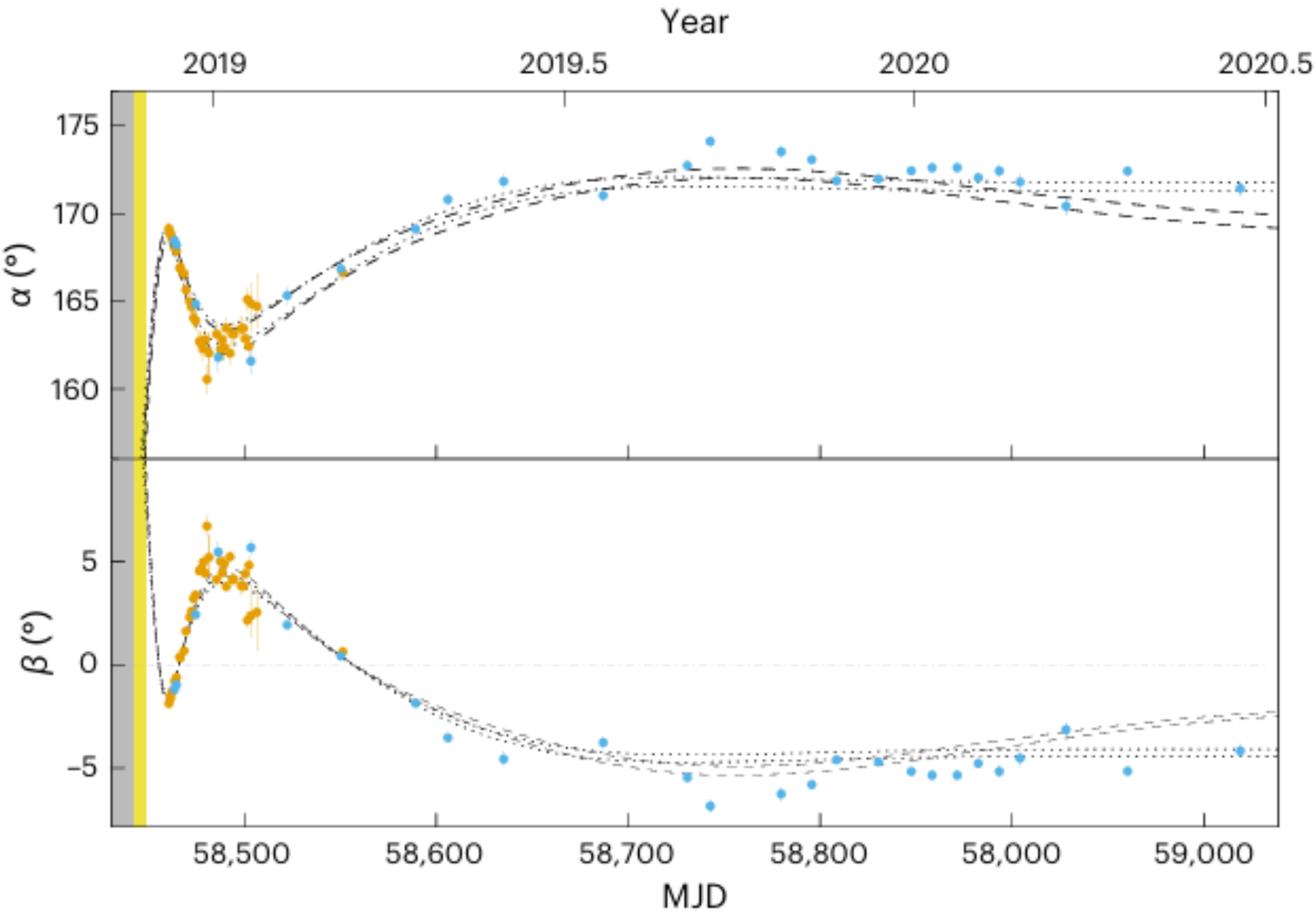
$$\zeta = \alpha + \beta$$

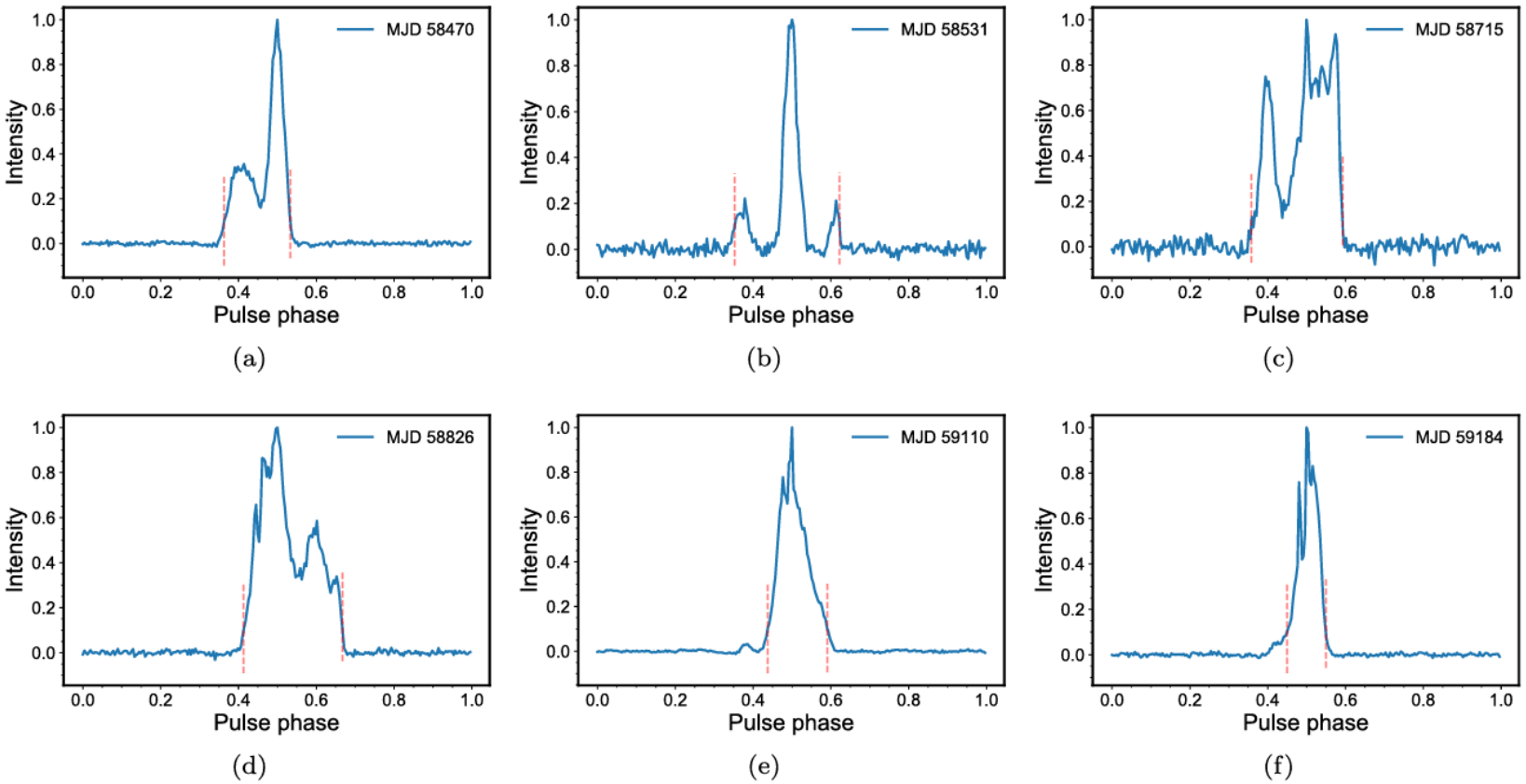
$$\tan\psi = \frac{\sin\alpha\sin\phi}{\cos\alpha\sin\zeta - \sin\alpha\cos\zeta\cos\phi}.$$

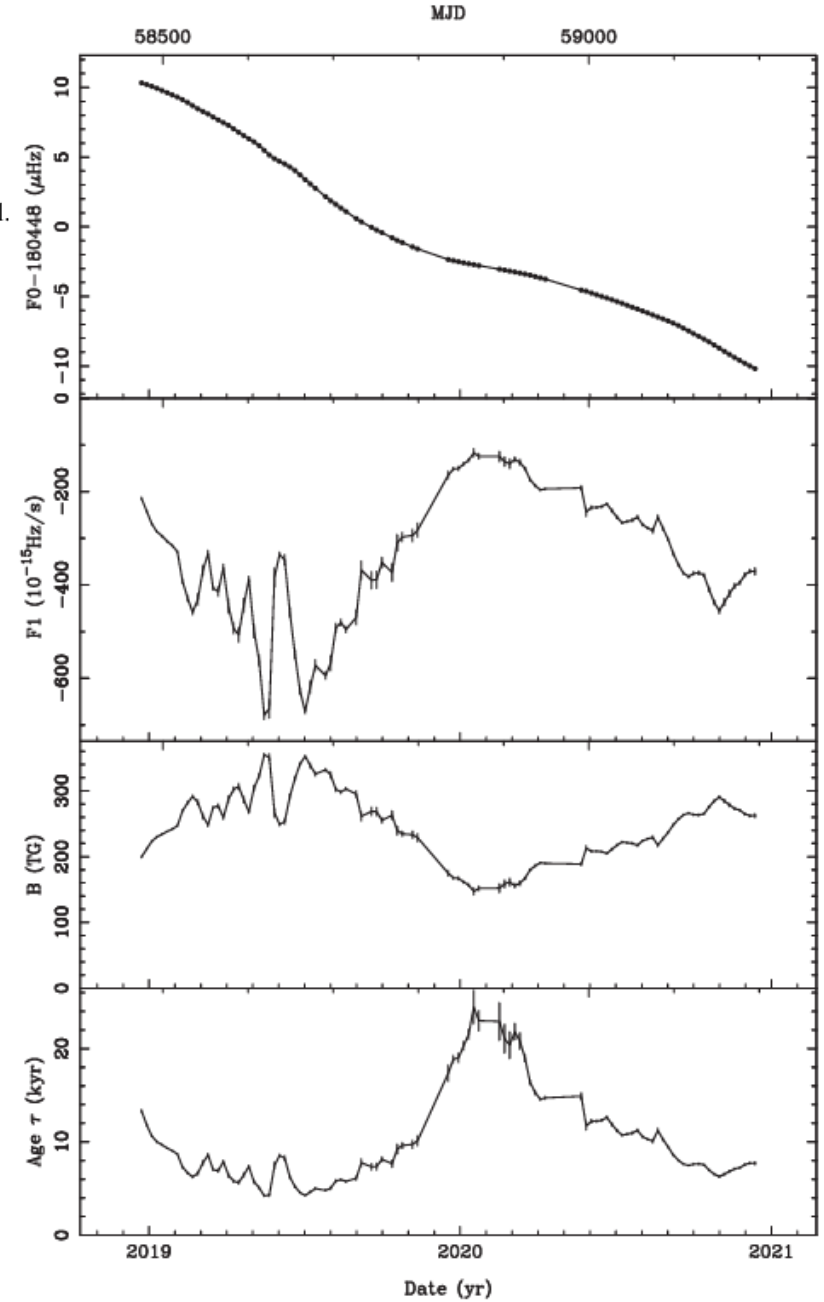
Data and Fitting

- Data: 62 polarimetric observations of XTE J1810-197 recorded with the Lovell and Effelsberg radio telescopes at 1.5 and 6 GHz, between Dec.8 2018 and Jun.18 2020

- They performed a simultaneous fit of the RVM to all PA data from our 62 epochs, with force precession or free precession model.
- The log-Bayes factor is ~75 in favor of the free-precession model and therefore unarguably supports, free precession against forced precession as the origin of the observed PA changes.


Year
2019
2019.5
2020
2020.5
175
170
165
160
α (°)
5
0
−5
β (°)
58,500
58,600
58,700
58,800
58,000
59,000
MJD


MJD 58470
MJD 58531
MJD 58715
MJD 58826
MJD 59110
MJD 59184
Intensity
Pulse phase
(a)
(b)
(c)
(d)
(e)
(f)


MJD
58500
59000
F0−180448 (μHz)
F1 (10^{-15}Hz/s)
B (TG)
Age τ (kyr)
2019
2020
2021
Date (yr)

Discussion and summary

- For XTE J1810–197, polarization variations of the magnetar radio emission as evidence for the magnetar undergoing free precession following the outburst while its magnetosphere slowly untwists.
- The observations of precession that damped on a timescale of months argue against the scenario of free precession magnetars as the origin of repeating FRBs.

Discussion and summary

- In summary, high-cadence radio and X-ray observations of magnetars, especially shortly after the detection of an outburst, are key to understanding the physics of free precession and could provide important information for testing the internal and magnetic structure of NSs.

Thank you

Discussion and summary

- Neutron stars with asymmetric deformation along an axis different from the rotation axis are expected to emit gravitational waves at both once and twice their rotation frequency. For slowly spinning NSs like magnetars and XTE J1810–197, the frequencies of the GW correspond to 0.18 and 0.36 Hz, falling in the frequency range (10−4 Hz to 1 Hz) of the Laser Interferometer Space Antenna gravitational wave observatory. But the magnitude of characteristic strain amplitude of the GW is several orders below the sensitivity.