Dependence of Pulsar death line on the equation of state

Xia Zhou, Hao Tong, Cui Zhu, Na Wang
Xinjiang Astronomical Observatory, CAS, China
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Outlines

- Motivations and backgrounds
- Pulsar death line and Equation of state
- Summary
Motivations

- Radio pulsars identified as neutron stars
- Spin period $P$ and spin down rate $\dot{P}$ can be obtained through timing measurement.
- The pulsars could be placed on the $P - \dot{P}$ plane
- Radio pulsar death line is defined as a line in the $P - \dot{P}$ diagram
Motivations

- Pulsar death line

  separates the pulsars that can produce radio emission from those that can not

\[ \Delta V = \Phi_{max} \]

potential drop across the accelerator \( \Delta V \)

the maximum potential drop \( \Phi_{max} \)

Motivations

• Pulsar death line

separates the pulsars that can produce radio emission from those that can not

\[ \Delta V = \Phi_{\text{max}} \]

 maximum acceleration potential \( \Phi_{\text{max}} = \frac{BR^3\Omega^2}{2c^2} \)

 surface dipolar magnetic field \( B = \sqrt{\frac{3lc^3P\dot{P}}{8\pi^2R^6\sin \theta^2}} \)

Motivations

Radio pulsars are just one observational manifestation of neutron stars. We have identified multiple other classes:

- RRATs, Intermittent pulsars
- Magnetars
- XDINS
- CCOs
Rotating Radio Transients (RRATs)

RRATs
- neutron stars which emit short (2-30 ms) radio pulses at intervals of minutes to hours
- have larger magnetic fields and spin periods

Intermittent pulsars
- part-time radio pulsars
- radio-loud/ radio-quiet
Magnetars

- Observationally, AXPs and SGRs are assumed to be magnetars
- Dipolar fields $\sim 10^{14} - 10^{15}$ G.
- Ages $\sim 10^3 - 10^5$ yrs
- Release of magnetic energy in all wavelength, including radio, optical/infrared, soft and hard X-ray etc.
X-ray dim isolated neutron star (XDINS)

- nearby sources with high surface dipole field $\sim 10^{13}$ G
- quasi-thermal X-ray emission with relatively low X-ray luminosity
- relatively long periodicities ($P = 3–11$ s)
- no radio emission
Central Compact Objects (CCO)

- compact stars lying at the center of the supernova remnant
- small hot spot in X-rays
- timing observations only find a very small surface dipole field
- no radio emission
Equation of state

\[ \Phi_{\text{max}} = \frac{BR^3 \Omega^2}{2c^2} \]

\[ B = \sqrt{\frac{3Ic^3P\dot{P}}{8\pi^2 R^6 \sin \theta^2}} \]
Equation of state

- The maximum mass: observational data $2.01(4)M_\odot$
- The smallest mass
  - neutron star: $0.2M_\odot$ (eos, bsk21)
  - strange star: $0.037M_\odot$ (eos, mMIT, $R_{small} = 4\text{km}$, CCO)

In order to compare the effect of equation of state on the pulsar death line, we choose different mass of neutron stars and quark stars. Corresponding moment of inertia are calculated through the ToV equation.
Equation of state

Neutron stars
M=0.2,0.5,1.0,1.4,2.0 M⊙

Quark stars
M=0.032,0.2,0.5,1.0,1.4,2.0 M⊙
Summary

• We offer a another point of view to understand the pulsar death line

• Central Compact Objects would be small mass of self-bound strange stars

• Rotating Radio Transients might be old pulsars on the verge of death

• PSR J2144-3933 would be a large mass pulsar, which would be larger than 2.0M☉

• Multiple observational facts would help us to reveal the nature of pulsars
Thank you for your attention!