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Difference and similarity in physics of millisecond and normal pulsars

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Abstract. MSP are very similar to NP, but need higher accelerating voltage, because of different emitting agent.

There are at least three distinctly different classes of neutron stars, generating a pulsed emission: normal pulsars (NP), with the period of rotation $P \sim 0.03 \div 4$ s and surface magnetic field (SMF) $\sim 10^{10} \div 10^{13}$ Gs; millisecond pulsars (MSP), rotating faster, $P \sim 0.0015 \div 0.03$ s, but their SMF is weaker — $10^7 \div 10^9$ Gs; at last, recently discovered slow rotating magnetars (MG), $P \sim 5 \div 20$ s, with strongest SMF $\sim 10^{14} \div 10^{15}$ Gs.

What is a physical reason of this difference? The answer may be prompted by the $P - \dot{P}$ diagram, plotted in "true physical" coordinates: accelerating voltage $U_{accel} \propto (\dot{P}/P^3)^{0.5}$ versus magnetic field strength at light cylinder (LCMF) $\propto (\dot{P}/P^5)^{0.5}$. Such representation is very convenient to demonstrate the difference/similarity between MSP and NP, which can be briefly summarized as follows:

1. MSP brunch grows from the NP "main sequence", stretches to the right and follows above in parallel, with the same slope.

2. Both MSP and NP brunches are limited by the same maximal value of LCMF $1.5 \cdot 10^6$ Gs (Crab pulsar and the original MSP J1939+2134).

3. NP and MSP have sharp but *different* "lines of death" (LOD), corresponding to the different critical accelerating voltage: $3 \cdot 10^9$ and $1.3 \cdot 10^{11} V$.

4. In contrast of normal sequence, which merely vanishes behind the NP-LOD, MSP brunch, reaching it's own line of death, bends down the main sequence, filling the gap between two brunches.

5. MSP brunch, shifted to the right along X-axis by the factor $U_{MSP\ LOD}/U_{NP\ LOD} \sim 43$, coincides with the top part of main sequence.

Thus, MSP are probably counterparts of NP, but need higher accelerating voltage. Properties of their radio emission are also the same, in spite of very different physical conditions (SMF etc.) inside magnetosphere (Manchester, 1992). The most attractive explanation is the follow: the same physics inside NP and MSP magnetosphere, including emission mechanism, but different emitting particles: traditional $e^{\pm}$ in NP, protons (antiprotons) in MSP (Kardashev 1999; Soglasnov 1999). If so, a squared ratio $U_{MSP\ LOD}/U_{NP\ LOD}$ equals proton-electron mass ratio, in accordance with the above analysis.

Magnetars represent an opposite case of neutron stars, with longer period and stronger magnetic field. At the diagram they form a brunch below NP sequence. Being continued to the left, MG brunch rests directly to "ha-ha-ha"

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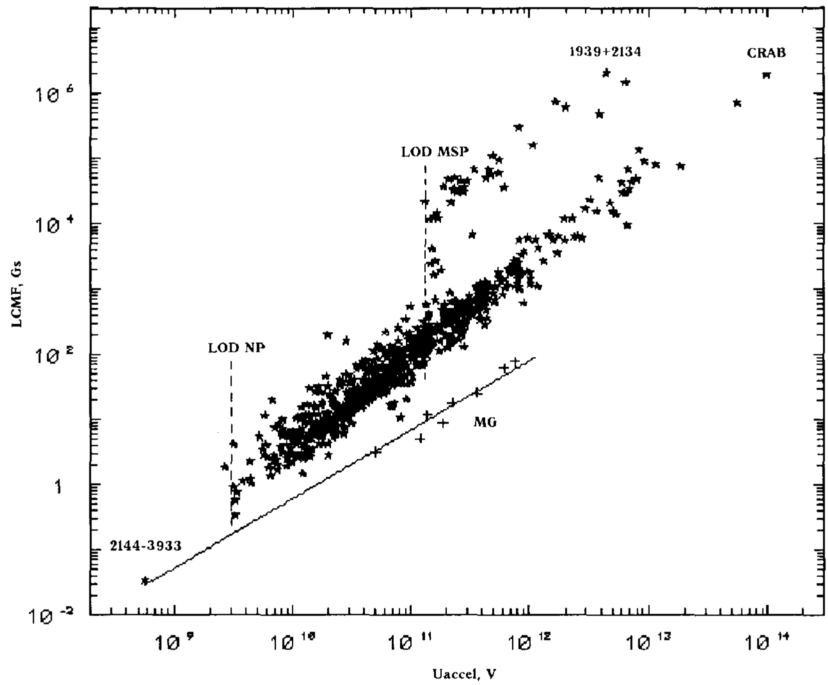

Figure 1. Magnetic field strength at light cylinder vs accelerating voltage for pulsars (stars) and eight magnetars (crosses).

pulsar J2144-3933 with 8.5 s period (Young et al,1999). Probably, this pulsar belongs actually not to NP but to MG brunch with different physics, so a pulsar's theory may be still alive.

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References

Kardashev, N. S. 1999 Synchrotron radioemission of protons and electrons in pulsars and nuclei of quasars, Preprint FIAN No 27; Astronomy Reports (submitted)

Manchester, R. N. 1992 Proc. IAU Colloquium No 128, eds. T. H. Hankins, J. M. Rankin, and J. Gill p. 204

Soglasnov, V.A. 1999 Astronomy Reports (submitted)

Young, M. D. Manchester, R. N. and Johnston, S. 2000, these Proceedings