

Surface-dependent sparking for coherent pulsar radio emission?

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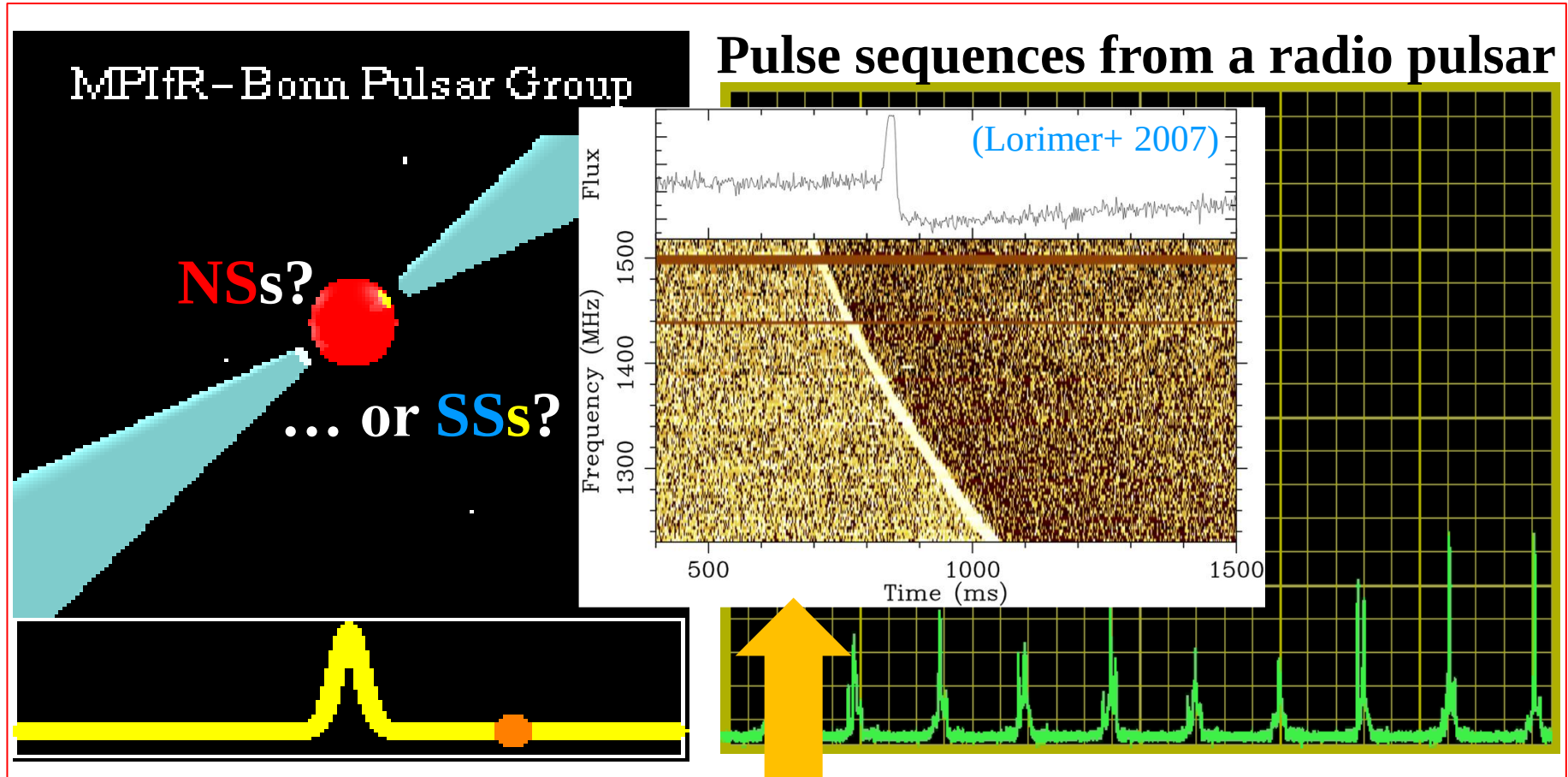
“The Era when **PSRs** meet **FRBs**”

May 15, 2025; FAST-Light Years Away, Guizhou, CHINA

Surface-depen. radio? <http://www.phy.pku.edu.cn/~xurenxin/> R. X. Xu

What is a pulsar made of?

Neutron **S**tar? **S**trangeon **S**tar? ... FRBs join in!



The Era when **PSRs** meet **FRBs**

Surface-dependent sparking for coherent pulsar radio emission?

Pulsar $\neq$ Neutron Star

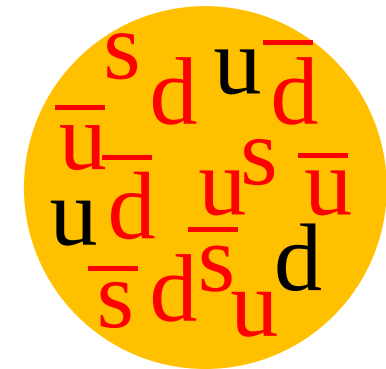
(Could a pulsar be a *proton* star? What is a *neutron*?...)

Pulsar ? Neutron Star?

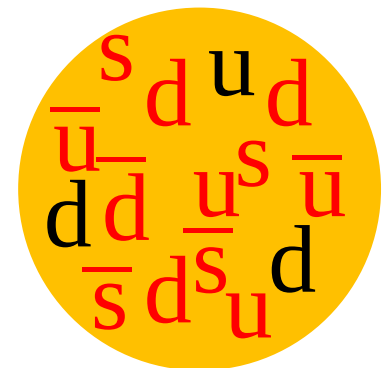
- What's a **n**eutron/**p**roton in the standard model?

$$(E_{\text{scale}} > \Delta m_{\text{uds}})$$

A perturbative calculation of quantum chromodynamics (QCD) may predict a nucleon sea with *light-flavor symmetry*, but the observed flavor asymmetry in the light-quark sea would be the result of the non-perturbative nature.



$$\mathbf{p} = \{u^2 d^1 s^0\}$$



$$\mathbf{n} = \{u^1 d^2 s^0\}$$

Strangeness and Hadron Structure

John Ellis^a

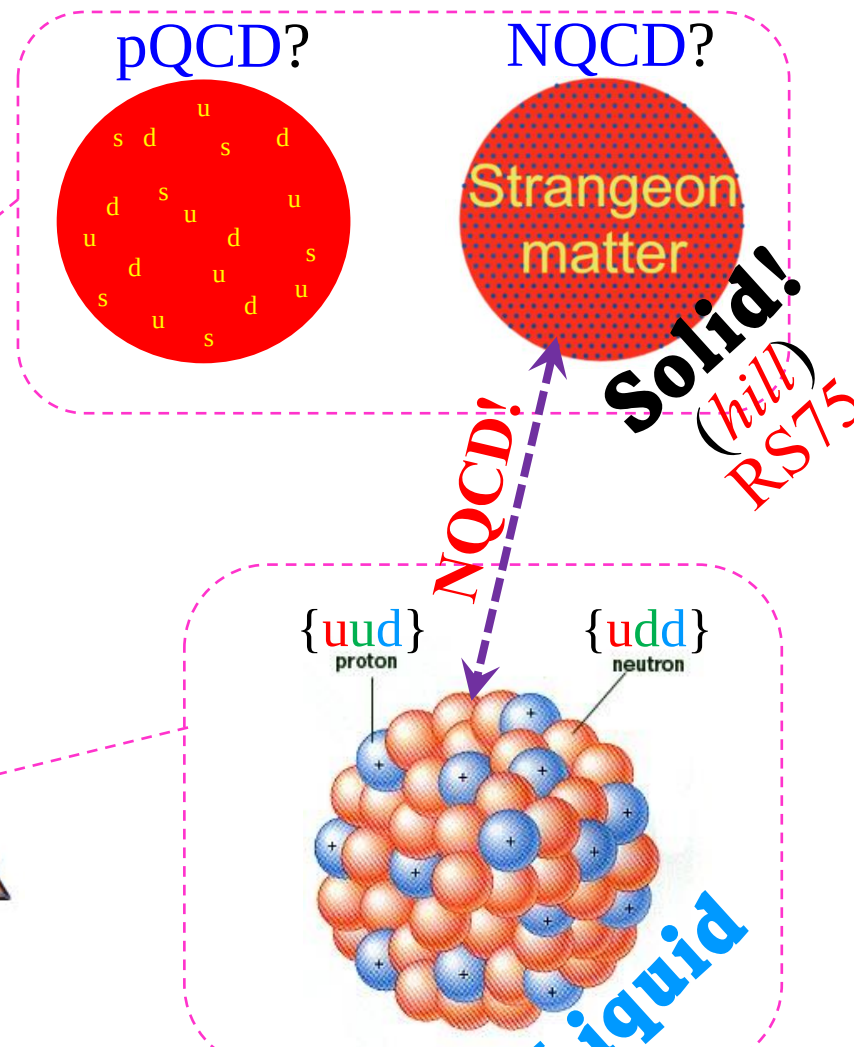
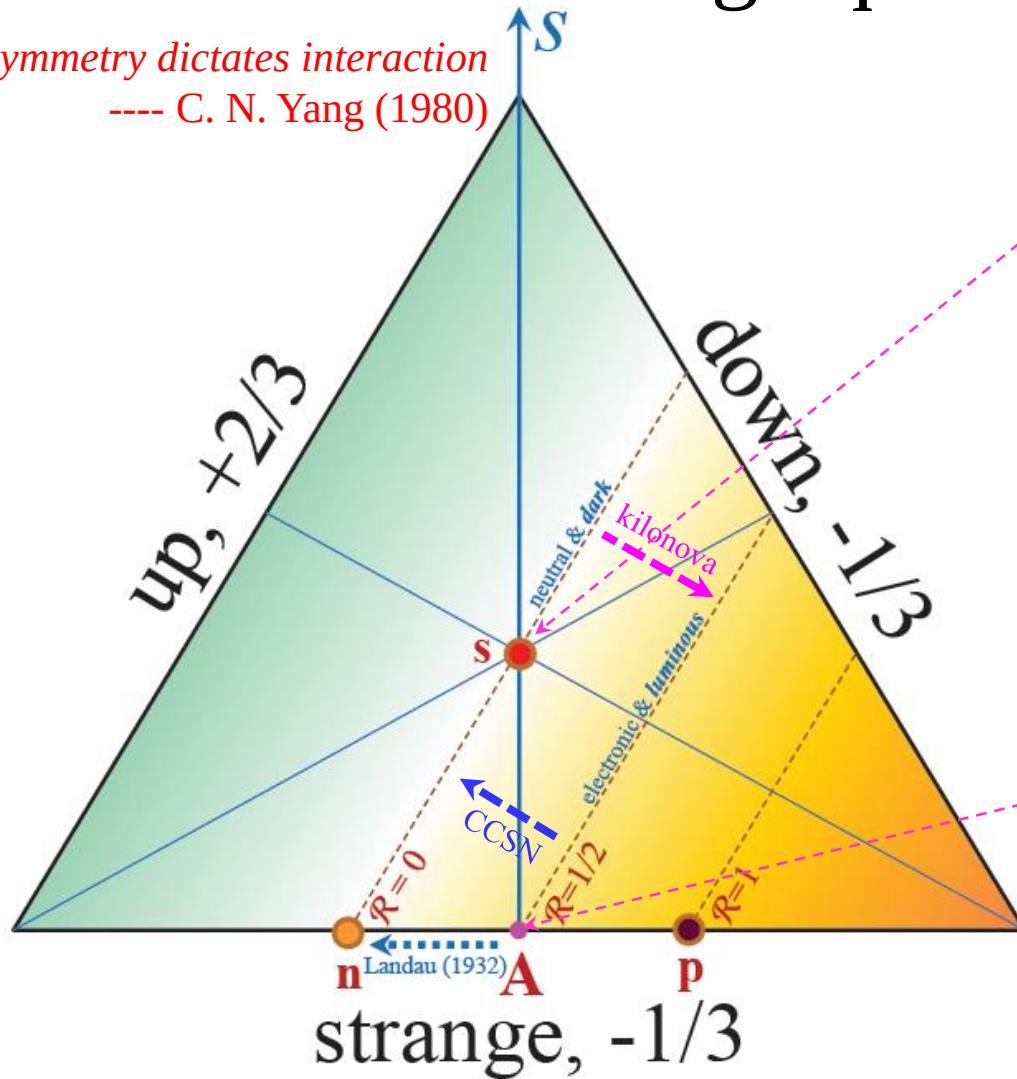
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The nucleon wave function may contain a significant component of $\bar{s}s$ pairs, according to several measurements including the π -nucleon σ term, charm production and polarization effects in deep-inelastic scattering. In addition, there are excesses of ϕ production in LEAR and other experiments, above predictions based the naive Okubo-Zweig-Iizuka rule, that may be explained if the nucleon wave function contains a polarized $\bar{s}s$ component. This model also reproduces qualitatively data on Λ polarization in deep-inelastic neutrino scattering. The strange component of the proton is potentially important for other physics, such as the search for astrophysical dark matter.

Pulsar ? Neutron Star?

- Neutron star? Strange quark star? *Strangeon* star?

Symmetry dictates interaction
---- C. N. Yang (1980)



Pulsar ? Neutron Star?

- Strangeon by multi-messenger

Lennard-Jones interaction:

$$U(r) = 4\epsilon \left[\left(\frac{\sigma}{r} \right)^{12} - \left(\frac{\sigma}{r} \right)^6 \right]$$

EoS:

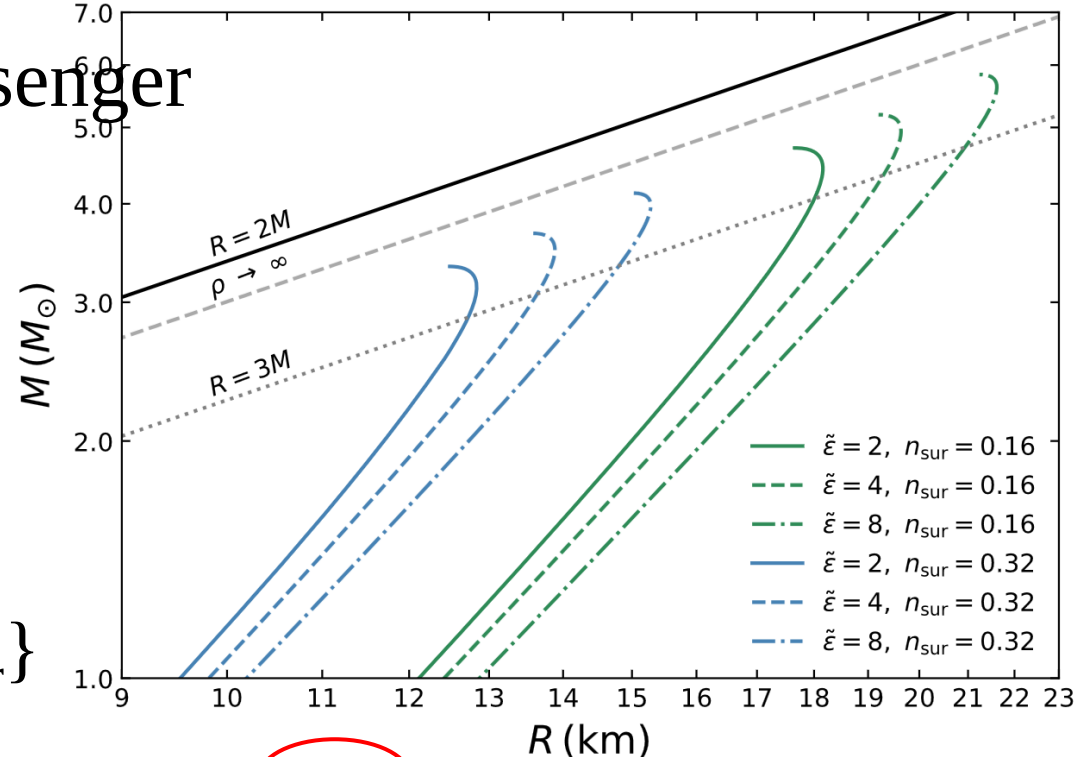
3-parameter set $\{N_q, \epsilon, n_{\text{sur}}\}$

2-parameter set $\{\tilde{\epsilon}, \bar{n}\}$

$$\tilde{\epsilon} = \epsilon / N_q$$

$$\bar{n} = N_q n / n_{\text{sur}}$$

(Yuan et al. 2025)



Three-parameter model ($N_q = 18$)	Prior	Case 1	Case 2	Case 3	Case 4
ϵ (MeV)	$\mathcal{U}(10, 170)$	$12.63^{+2.52}_{-1.87}$	$11.02^{+1.61}_{-0.73}$	$11.76^{+1.97}_{-1.35}$	$11.62^{+1.88}_{-1.13}$
$[\epsilon/N_q]$ (MeV)		$0.70^{+0.14}_{-0.10}$	$0.61^{+0.09}_{-0.04}$	$0.65^{+0.11}_{-0.08}$	$0.65^{+0.10}_{-0.06}$
n_{sur} (fm $^{-3}$)	$\mathcal{U}(0.17, 0.36)$	$0.23^{+0.03}_{-0.03}$	$0.22^{+0.02}_{-0.02}$	$0.22^{+0.02}_{-0.02}$	$0.19^{+0.01}_{-0.01}$
$R_{1.4}$ (km)		$11.32^{+0.76}_{-0.61}$	$11.33^{+0.66}_{-0.48}$	$11.47^{+0.60}_{-0.51}$	$12.04^{+0.27}_{-0.31}$
$\Lambda_{1.4}$		$160.95^{+53.30}_{-45.68}$	$161.49^{+49.91}_{-31.94}$	$170.44^{+48.07}_{-40.62}$	$205.60^{+32.49}_{-32.53}$
$R_{2.0}$ (km)		$12.59^{+0.71}_{-0.81}$	$12.56^{+0.72}_{-0.62}$	$12.62^{+0.69}_{-0.60}$	$13.28^{+0.24}_{-0.35}$
M_{TOV} ($M_\odot$)		$3.51^{+0.22}_{-0.10}$	$3.48^{+0.21}_{-0.10}$	$3.51^{+0.18}_{-0.09}$	$3.58^{+0.16}_{-0.12}$
$n_c(n_0)_{M_{\text{TOV}}}$		$4.71^{+0.57}_{-0.51}$	$4.71^{+0.57}_{-0.42}$	$4.71^{+0.54}_{-0.42}$	$4.19^{+0.01}_{-0.24}$
Two-parameter model	Prior	Case 1	Case 2	Case 3	Case 4
$\tilde{\epsilon}$	$\mathcal{U}(0.3, 3)$	$0.62^{+0.19}_{-0.14}$	$0.48^{+0.11}_{-0.08}$	$0.54^{+0.10}_{-0.10}$	$0.61^{+0.09}_{-0.07}$
n_{sur} (fm $^{-3}$)	$\mathcal{U}(0.17, 0.36)$	$0.22^{+0.03}_{-0.03}$	$0.20^{+0.02}_{-0.02}$	$0.20^{+0.02}_{-0.02}$	$0.18^{+0.01}_{-0.01}$
$R_{1.4}$ (km)		$11.43^{+0.71}_{-0.73}$	$11.65^{+0.48}_{-0.62}$	$11.69^{+0.58}_{-0.51}$	$12.16^{+0.26}_{-0.31}$
$\Lambda_{1.4}$		$164.33^{+72.42}_{-50.81}$	$193.95^{+58.01}_{-54.29}$	$193.35^{+64.17}_{-46.92}$	$212.36^{+53.71}_{-32.66}$
$R_{2.0}$ (km)		$12.51^{+0.79}_{-0.86}$	$12.66^{+0.64}_{-0.66}$	$12.95^{+0.53}_{-0.71}$	$13.38^{+0.27}_{-0.41}$
M_{TOV} ($M_\odot$)		$3.52^{+0.17}_{-0.08}$	$3.49^{+0.19}_{-0.11}$	$3.51^{+0.17}_{-0.12}$	$3.65^{+0.18}_{-0.16}$
$n_c(n_0)_{M_{\text{TOV}}}$		$4.41^{+0.18}_{-0.63}$	$4.73^{+0.37}_{-0.48}$	$4.46^{+0.36}_{-0.20}$	$3.94^{+0.02}_{-0.26}$

Surface-dependent sparking for coherent pulsar radio emission?

Surface-depen. Radio?

(Mountain building on the *Earth*, so does the *strangeon star*...)

Surface-depen. Radio?

● Zits on face?

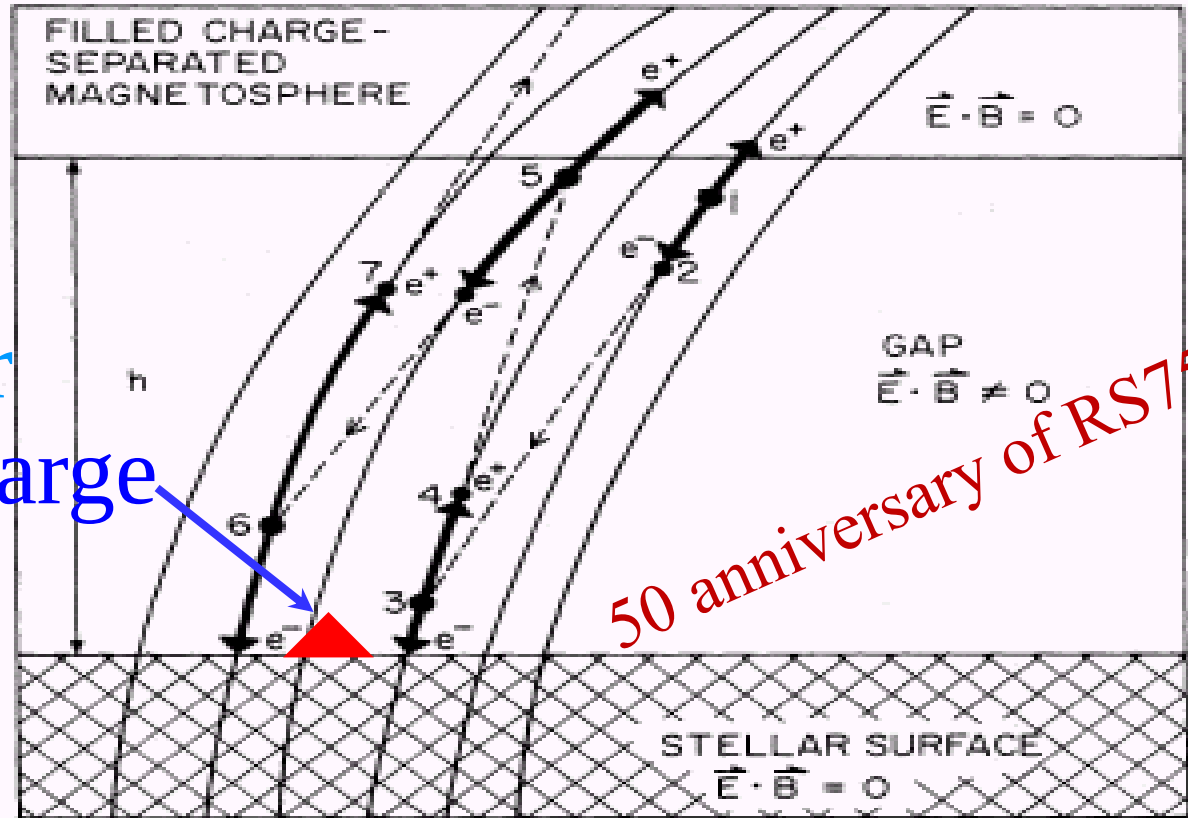
$$E_{\parallel, \text{peak}} \gg E_{\parallel, \text{plain}}$$

Lightning arrester
Preferential discharge

Modes/nulling?

Swooshes?

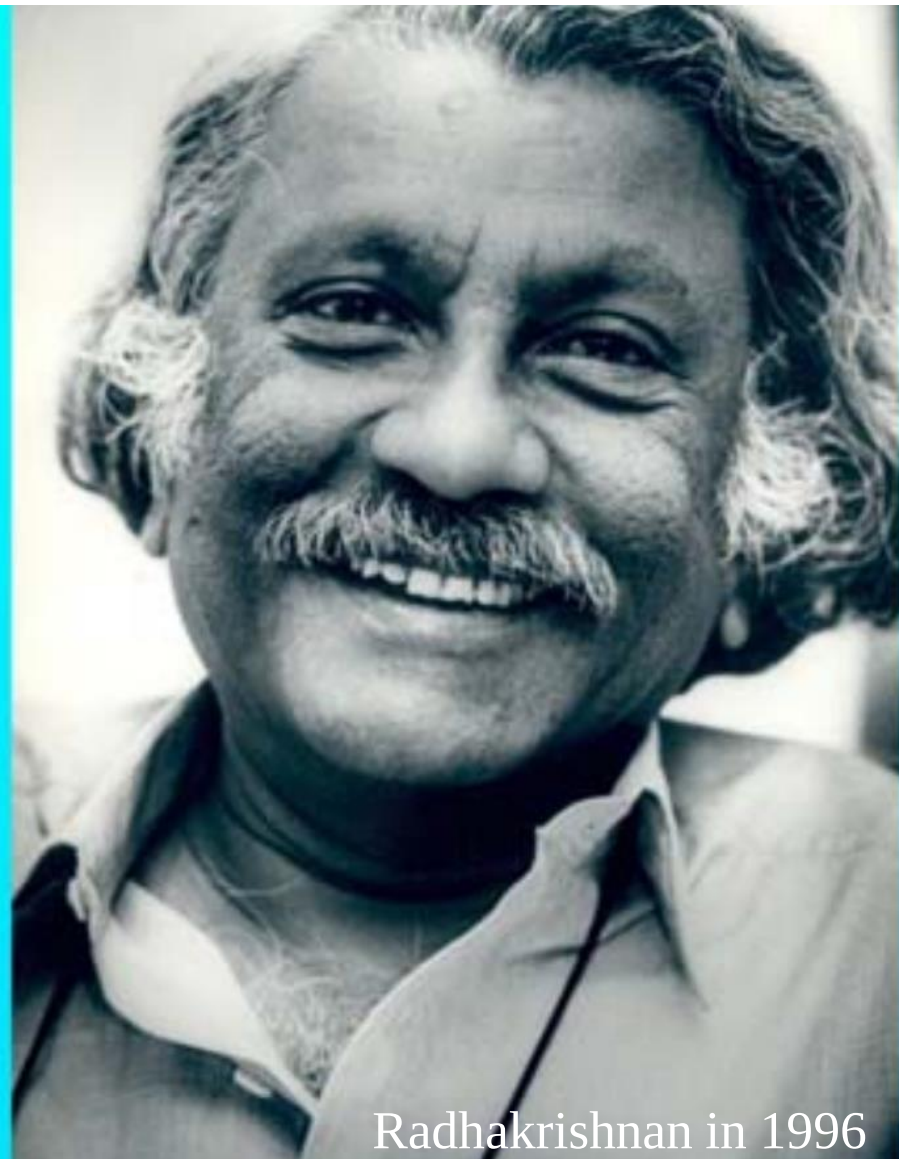
Jitters?



Stable zits could not exist on NS surface:

$$\gamma^{1/2} m_e c^2 \sim \gamma_6^{1/2} \text{ GeV} \gg \hbar e B / (m_e c) \sim B_{14} \text{ MeV}$$

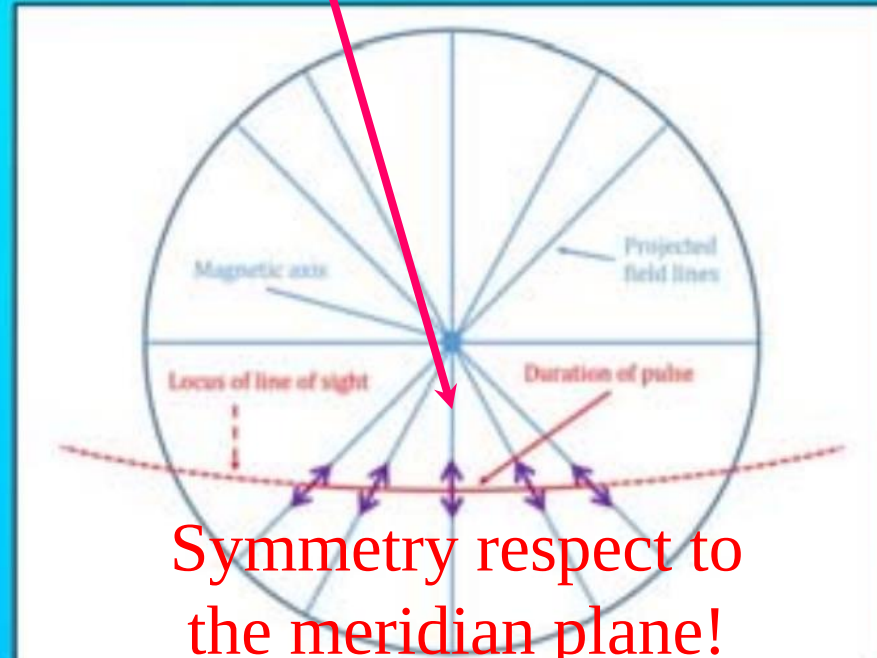
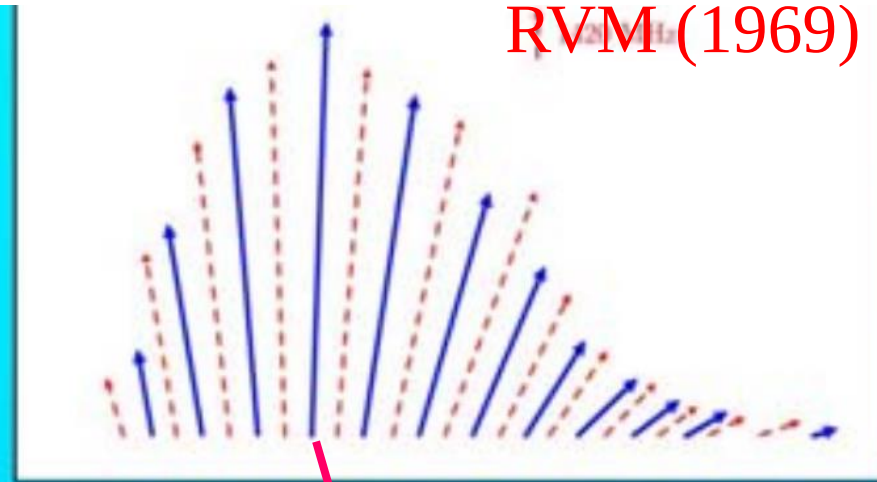
Surface-depen. Radio?



Radhakrishnan in 1996

from Manchester (2017)

RVM (1969)



Symmetry respect to
the meridian plane!

Surface-depen. Radio?

What if zits on surface?

COVER PICTURE

Free Access

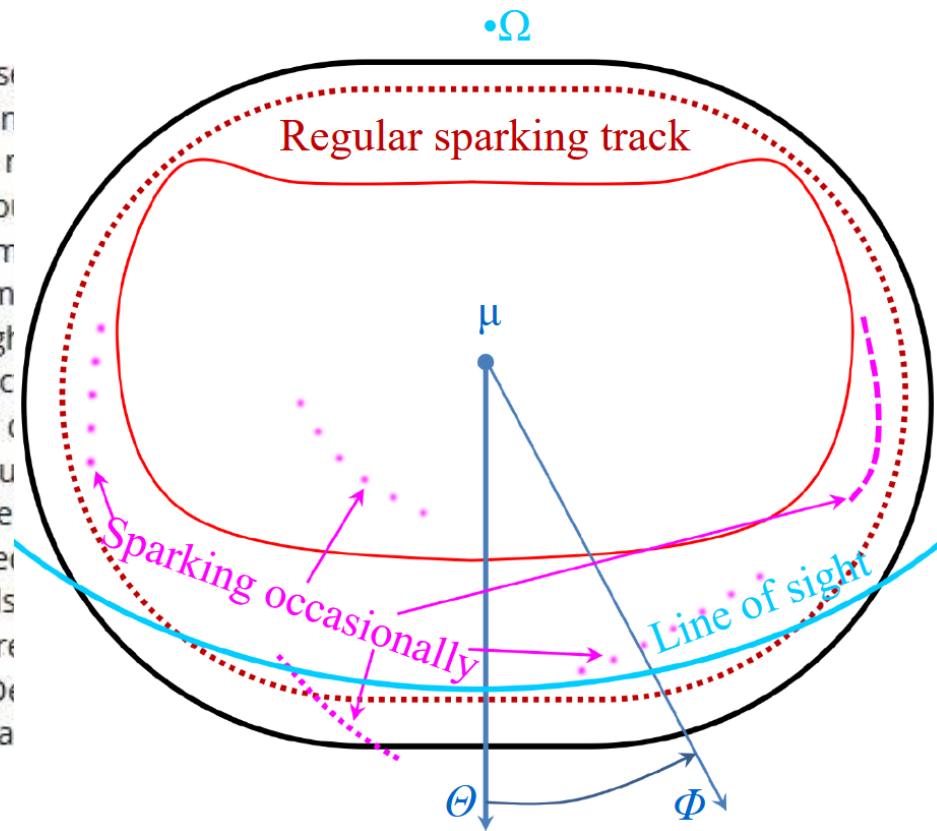
Cover Picture: Astron. Nachr. 2/2024

Zhengli Wang, Jiguang Lu, Jingchen Jiang, Shunshun Cao, Weiyang Wang, Enwei Liang, Renxin Xu

e249012 | First Published: 24 March 2024



It has been proposed that matter could be 'an strangeon star should be covered with small spots in this schematic pulsar surface might magnetospheric acceleration radio emission, as (and Wang, this issue responsible for the sparking discovered observation of pulsars China's Five-hundred Telescope, FAST. Do contribution by Wang



Surface-depen. radio?

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Surface-depen. Radio?

- Now is the era with the FAST!

running since 2019...

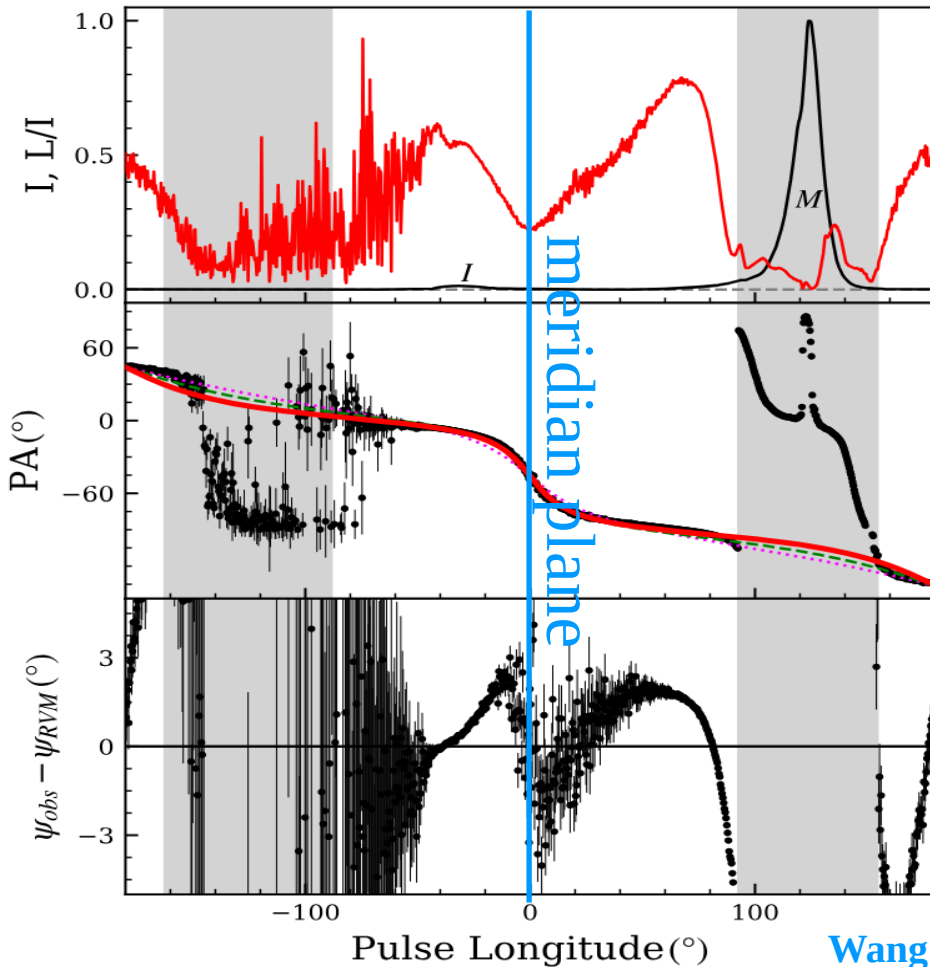


Fig. 1 Panoramic view of FAST (obtained in June of 2017).

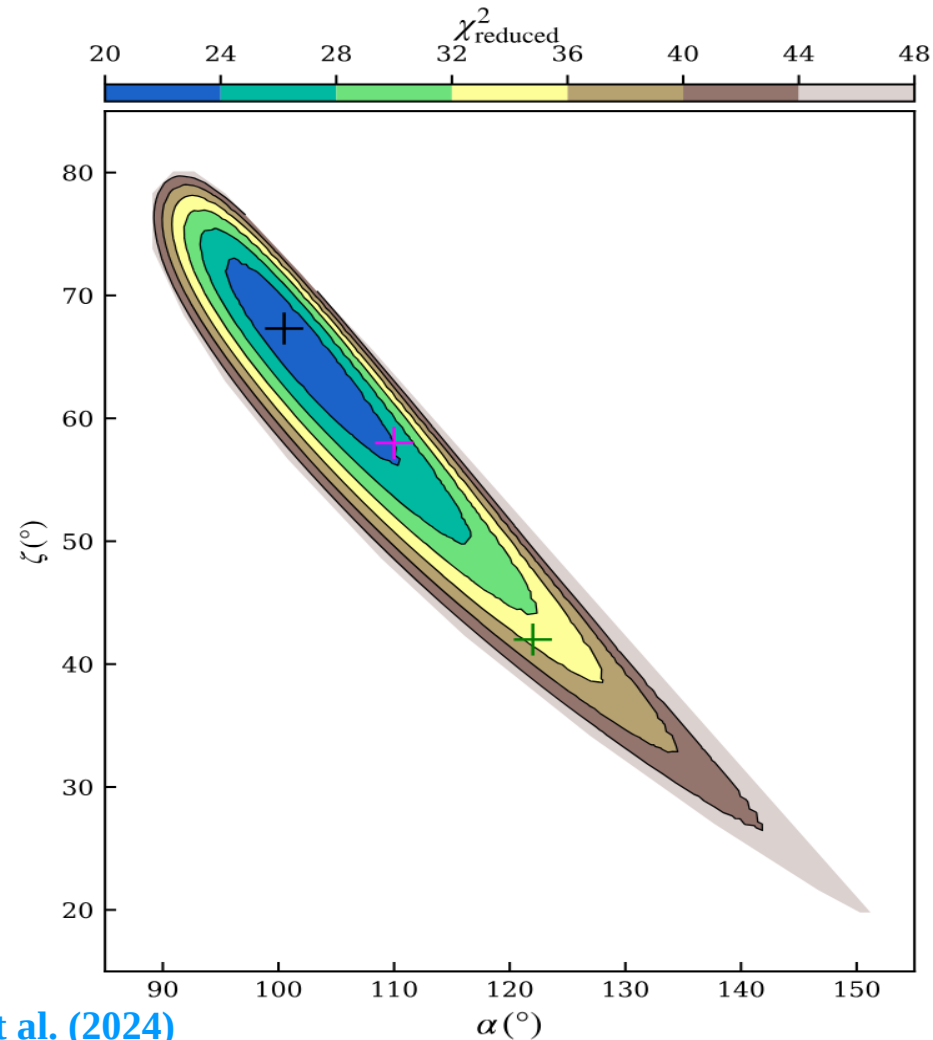
Surface-depen. Radio?

- Strong particle-binding and “zits” on PSR surface

PSR B0950+08



Wang et al. (2024)

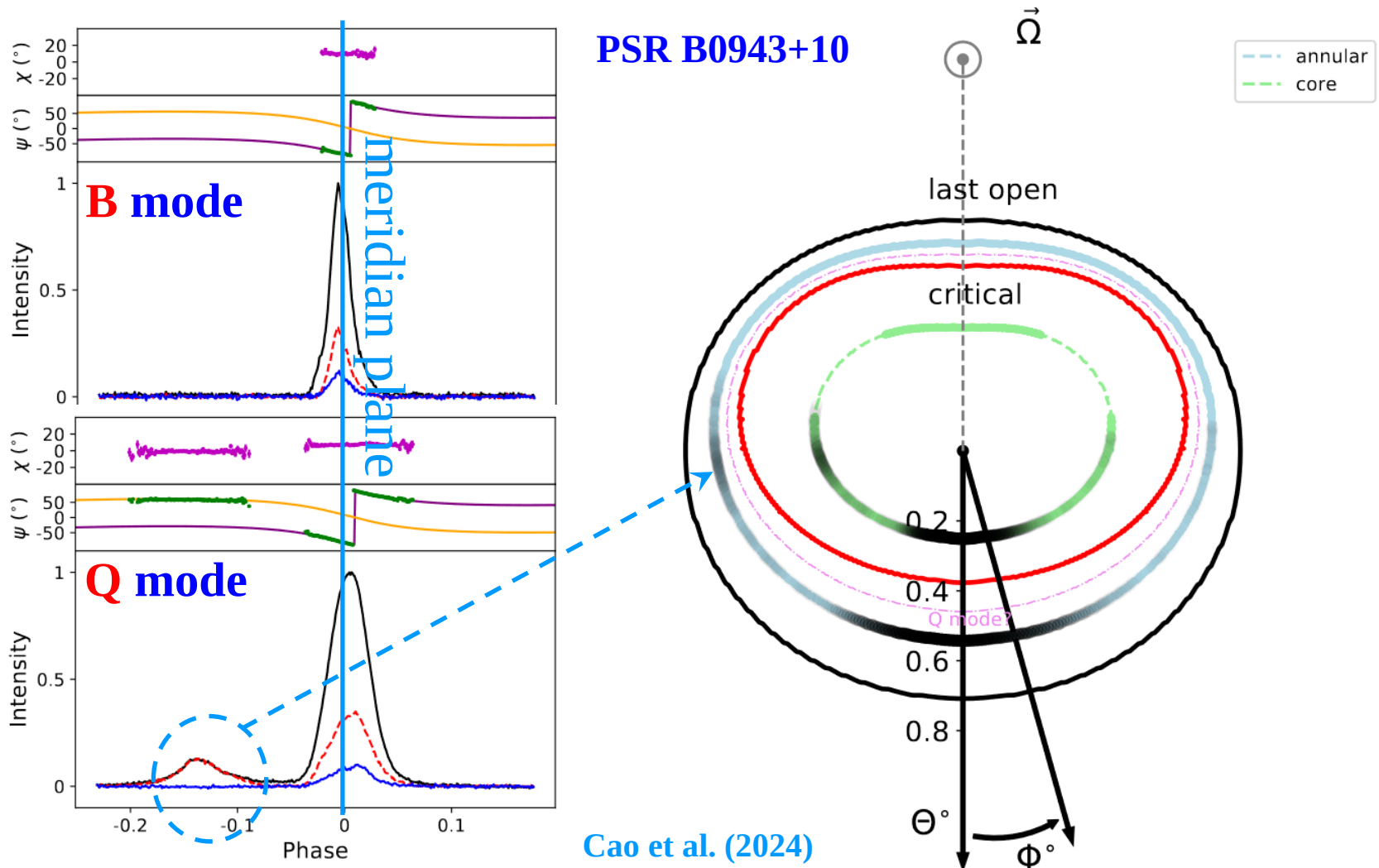


Surface-depen. radio?

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Surface-depen. Radio?

- Strong **particle-binding** and “**zits**” on PSR surface



Surface-dependent sparking for coherent pulsar radio emission?

Summary

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- We proposed that radical idea that pulsars are *strangeon* stars, a kind of nucleon-like multi-quark bound state with almost equal numbers of up, down and strange valance quarks (likely $6 \times 3 = 18$).
- Small *hills* (*zits*) could exist on the surface of a pulsar if pulsars are strangeon star. Preferential discharges may occur around zits for produce pair plasma, as an analogy of lightning arrester.
- ...really strange?

The Tumultuous Birth of Quantum Mechanics

(by Phillip Ball)

February 4, 2025 • *Physics* 18, 24

The creation of modern quantum mechanics was a messy business in which many of the participants did not grasp the significance of their own discoveries. *it was just an *ad hoc* “trick”*

The exception was Albert Einstein, who in 1905 proposed that Planck’s formula for the energy of a vibrational mode $E = h \nu$ be applied to light [4]. There had been no suggestion of that in Planck’s work on blackbody radiation, and Einstein’s reasoning now looks remarkably casual for so radical a proposal.

... But while Kuhn paints a picture of scientists clinging conservatively to old ideas for as long as they can, history suggests that *radical new ideas are often not so much resisted as simply ignored or overlooked* — sometimes even by those who conceive of them.

THANKS!