

Sarith Chopara (Rith)

B.Sc. Physics @ Mahidol Uni, Thailand

M.Sc. High Energy Physics (HEP) @ IP Paris, France (ongoing)

Advisor : Dr. Peera Simakachorn, Khon Kaen Particle Physics and Cosmology Theory Group (KKPaCT), Khon Kaen University

- Topological Defects
- Axion / Axion-like particles
- ...

QCD Phase Transition & Domain Wall (DW)

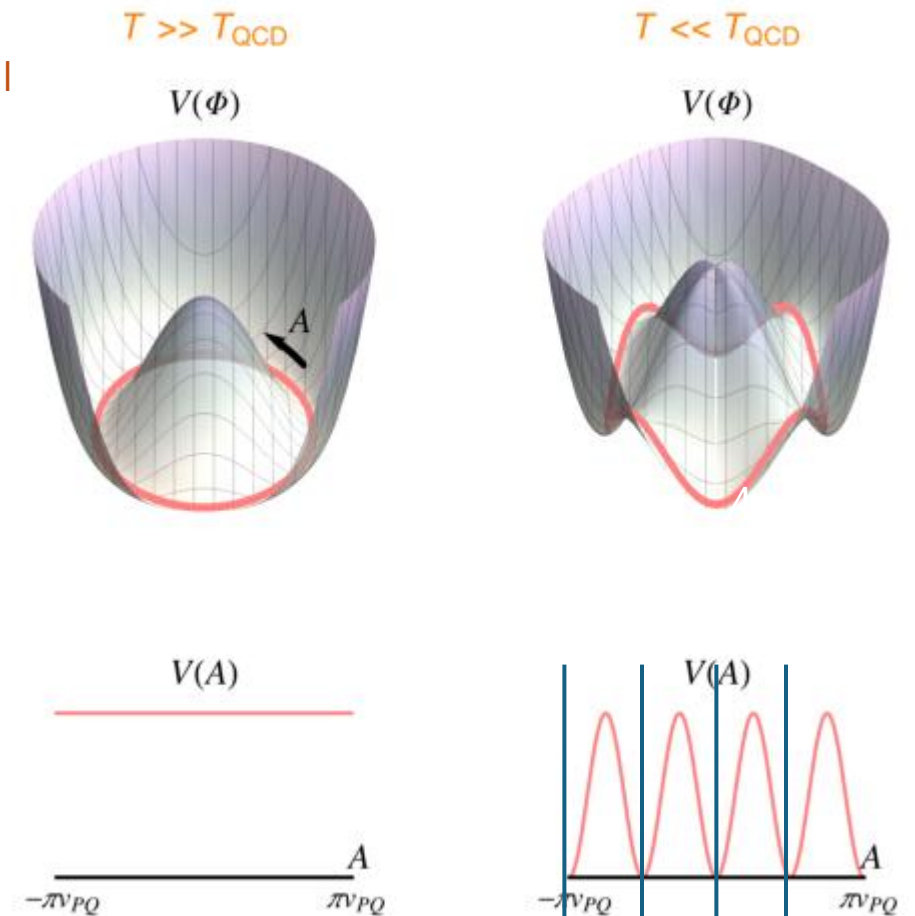
Axion is coupled to gluon fields through Quantum Chromodynamics (QCD) interaction, producing an **effective potential**

$$V(a) = \Lambda_{\text{QCD}}^4 \left[1 - \cos \left(\frac{1}{f_a} a \right) \right] \quad (\text{conventional})$$

$$V(a) = \Lambda_{\text{QCD}}^4 \left[1 - \cos \left(\frac{N_{\text{DW}}}{v_{PQ}} a \right) \right]$$

Each vacuum is separated from the next by a barrier

→ Domain Wall (defect)



DW Problem & DW Decay

It can be derived that

Domain Wall Energy density per Area $\sigma_{DW} = \frac{8m_a v_{PQ}^2}{N_{DW}^2}$

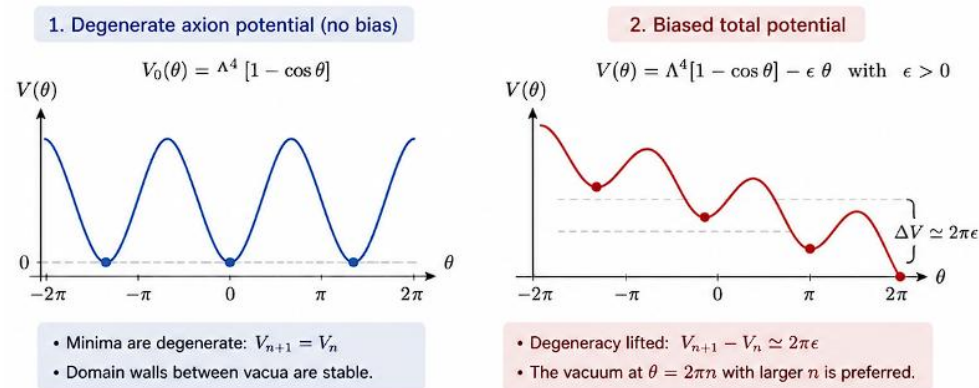
Energy Density $\rho \sim R^{-1} \sim H$ can dominate the Universe

But we do not observe! → **DW Problem**

(DW extend through the string-wall network)

- Introducing some bias field to interact with PQ axion

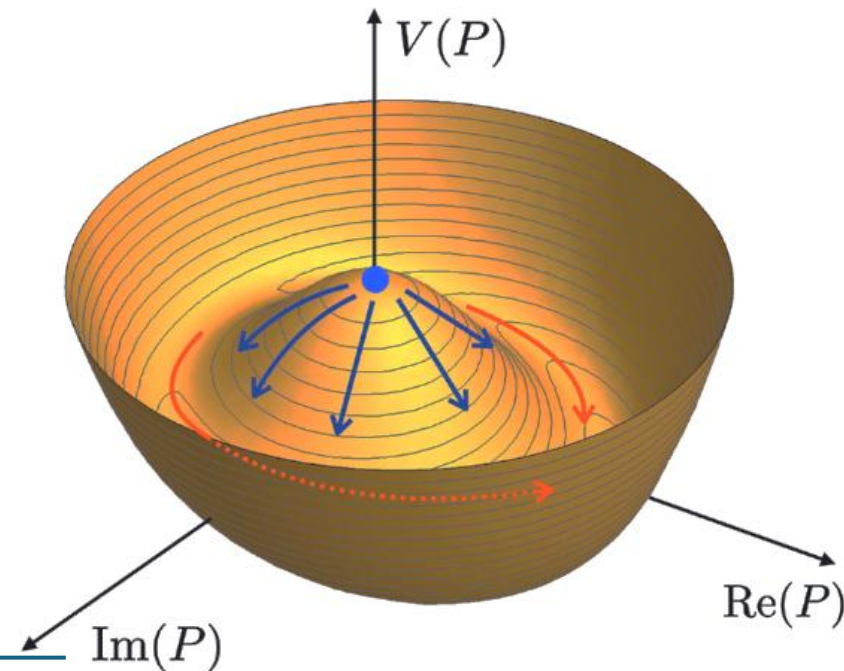
→ Causing a biased potential term → only one true vacuum → DW decay



- Following Ibe et al. (2020) and Hao et al. (2025), introduce a bias field S coupled to P :

$$V(P, S) = \lambda_P \left(|P|^2 - \frac{v_{PQ}^2}{2} \right)^2 + \frac{\lambda_S^2}{(n!)^2 M_{Pl}^{2n-4}} |S|^{2n} \\ + m_S^2 |S|^2 + \left(\frac{\lambda}{m! \ell! M_{Pl}^{m+\ell-4}} S^m P^\ell + \text{h.c.} \right)$$

- The mixing term $S^m P^\ell$ creates a **bias potential** — a tilt lifting the degeneracy between vacua.

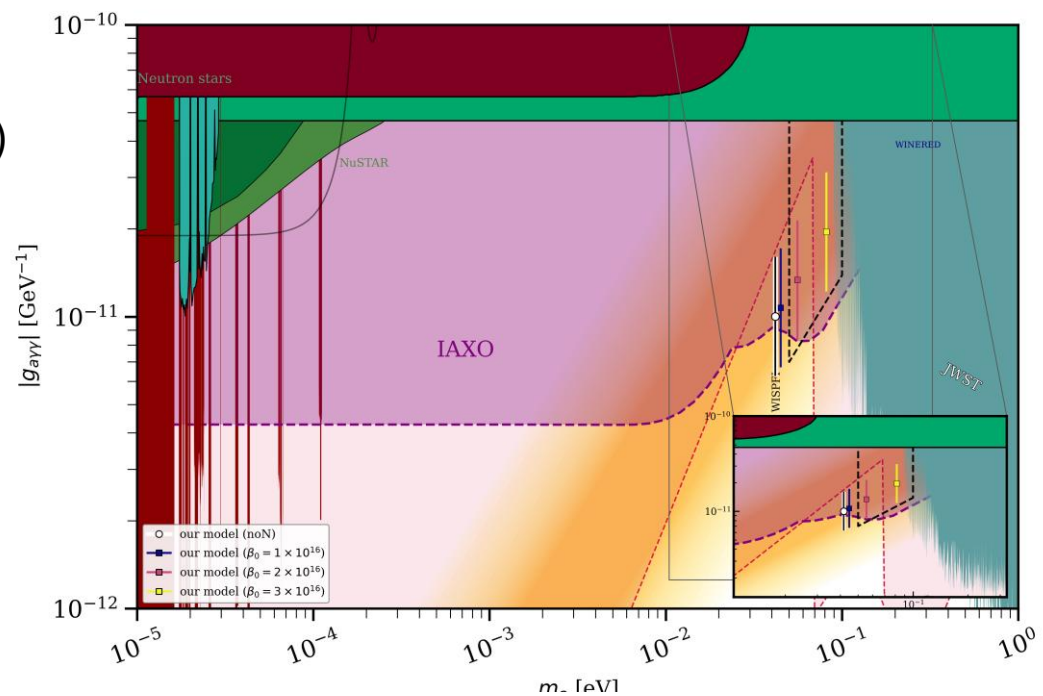


KSVZ axion coupling:

$$g_{a\gamma\gamma} = -\frac{\alpha}{2\pi f_a} (1.92)$$

(My Work)

- Model sits within reach of **IAXO**
- Higher β_0^{scale} accessible by **JWST**
- Connects particle theory to next-gen labs



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