

# Visible Heavy QCD Axion

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# Strong CP Problem

- There *is* a problem
- Peccei-Quinn mechanism is the most popular solution
  - $U(1)_{PQ}$  makes  $\theta$  unphysical
- But, why is  $U(1)_{PQ}$  a symmetry?

# What if $U(1)_{PQ}$ is broken?

$$\Delta\mathcal{L} = \frac{\phi^5}{M_{Pl}}$$

$$\Rightarrow \mathcal{L} \sim -m_a^2 a^2 + \frac{f_a^4 a}{M_{Pl}}$$

$$\Rightarrow \Delta\theta \sim \frac{f_a^3}{M_{Pl} m_a^2} \gg 10^{-10},$$

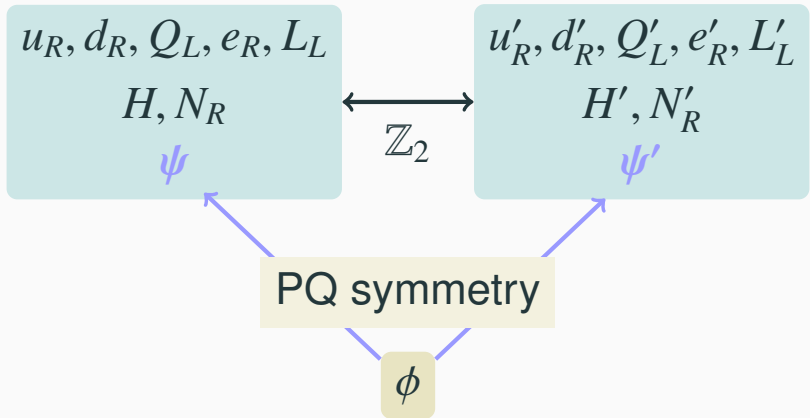
- Can we make  $a$  heavier?

# Rubakov mechanism

- Usually,  $f_a$  fixes  $a$  mass
- But, if there is a *copy* of SM,  $a$  can be heavier

Rubakov, 1997

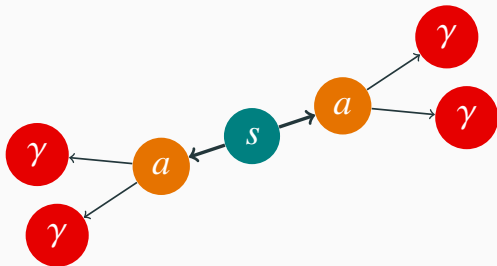
# Our Model



HF, Harigaya, Ibe and Yanagida,  
arXiv:1504.06084

# LHC signature

- A particle leads “ $\gamma$ -jet” signal



HF, Ibe, Jinnouch and Nojiri,  
arXiv:1607.01936

- We try to distinguish  $\gamma$ -jet from  $\gamma$

# Summary

- We construct a model of a heavy QCD axion
- We study an LHC signal of photon-jets