Axions and anomalous $U(1)$'s

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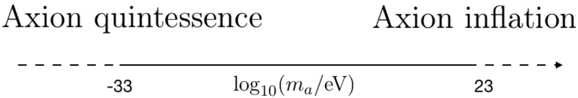

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Constrained by **numerous complementary experiments**

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  $\Longrightarrow$ **light NGB** with model-dependent couplings

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$\Longrightarrow$ **anomaly-given axion with anomaly-given gauge couplings**

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- can those axions be **QCD axions**?
- ...

I. Anomalous $U(1)$ theories: physical axions and gauge couplings

$$\mathcal{L} \supset -\overline{\psi}_i \not{D} \psi_i - \frac{1}{2}(\partial_\mu \theta - \delta_{GS} A_{X,\mu})^2 + \frac{k_G}{16\pi^2} \theta \, \mathrm{Tr}\left(G\tilde{G}\right) + ...$$

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Ex: $SU(5)$ unification of the SM gauge group:

$$\frac{5}{3}k_Y = k_2 = k_3 \implies \boldsymbol{\frac{E}{N} = \frac{8}{3}} \text{ (at the GUT scale)}$$

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Heterotic string theory: **one** possible **anomalous $\boldsymbol{U(1)_X}$** and **one (axion-dilaton) field**

$$\mathcal{L} = \mathcal{L}_{GS} + \mathcal{L}_{\text{matter}}$$

$$\mathcal{L}_{GS} = -\int d^4\theta \ln\left(S + \overline{S} - \delta_{GS} V_X\right) + \int d^2\theta \frac{k_G S}{4} \,\text{Tr}(W_G^{\alpha} W_{G,\alpha}) + h.c.$$

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In this setup: **a/only one physical axion, string/GUT scale decay constant**

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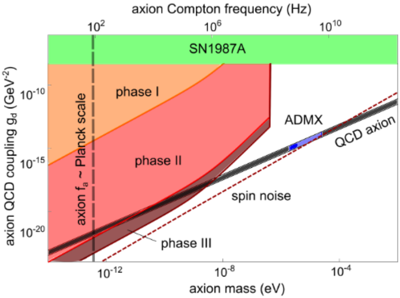
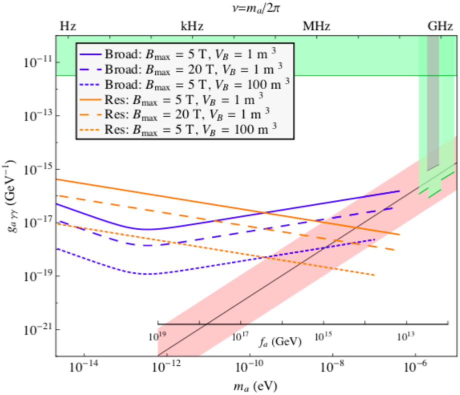


Kimball et al., arXiv:1711.08999



Kahn-Safdi-Thaler, *PRL* 117 (2016)

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- $\rightarrow$ **anomaly predictions for SM gauge field couplings**
- $\rightarrow$ **spin couplings correlated with mass matrix entries**:

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Bounds from meson physics: $\boldsymbol{f_a \gtrsim 10^{10-11}}$**GeV**

Calibbi-Goertz-Redigolo-Ziegler-Zupan (2016), Ema-Hamaguchi-Moroi-Nakayama (2016)

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QCD axion if QCD mass dominates ($m_{\text{rest}} f_a \lesssim 10^{-5} m_\pi f_\pi$)

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Tied to stabilization details (and possibly SUSY breaking, ...).

Bonnefoy-Dudas, arXiv:1809.xxxxx

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Their associated **high-scales** may be **within reach of** proposed/developed/current **experiments**.

Thank you!