The Minimal Flavour Violating Axion/ALP Model

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Based on: FAA, L. Merlo, The Minimal Flavour Violating Axion, 1709.07039
FAA, F. D'Eramo, L. Merlo, A. Notari, R. Zambujal-Ferreira; work in progress

MOTIVATION

Study Goldstone Bosons arising from a spontaneously broken flavour symmetry

Axion ($m_a \lesssim 0{,}1$ GeV)

- Natural origin for the PQ Symmetry from flavour ✓
- Strong CP Problem [1] + BSM Flavour Problem ✓
- DM + detection by Astrophysics and Cosmology ✓

ALP ($m_a \gtrsim 0{,}1$ GeV)

- BSM Flavour Problem ✓
- Low NP scale ✓
- Detection through collider signatures ✓

THE MODEL

- PQ symmetry identified within the MFV [2] symmetry group

$$G_F = U(3)_{Q_L} \times U(3)_{u_R} \times U(3)_{d_R} \times U(3)_{L_L} \times U(3)_{e_R} \supset U(1)_B \times U(1)_L \times U(1)_Y \times U(1)_{PQ} \times U(1)_{e_R}$$

- Generation independent charges → Flavour conserving but **non-universal** couplings to fermions
- New complex scalar (Froggatt-Nielsen [3]) makes Yukawas invariant under PQ
- Yukawas are spurions under the non-Abelian symmetries

$$\Phi = \frac{\phi + v_\phi}{\sqrt{2}} e^{\frac{ia}{f_a}}$$

$$\mathcal{L}_Y = \left(\frac{\Phi}{\Lambda_\Phi}\right)^{x_d - x_Q} \bar{Q}_L H d_R \mathcal{Y}_d + \left(\frac{\Phi}{\Lambda_\Phi}\right)^{x_u - x_Q} \bar{Q}_L \tilde{H} u_R \mathcal{Y}_u + \left(\frac{\Phi}{\Lambda_\Phi}\right)^{x_e - x_L} \bar{L}_L H e_R \mathcal{Y}_e + h.c.$$

PHENOMENOLOGY

Axion

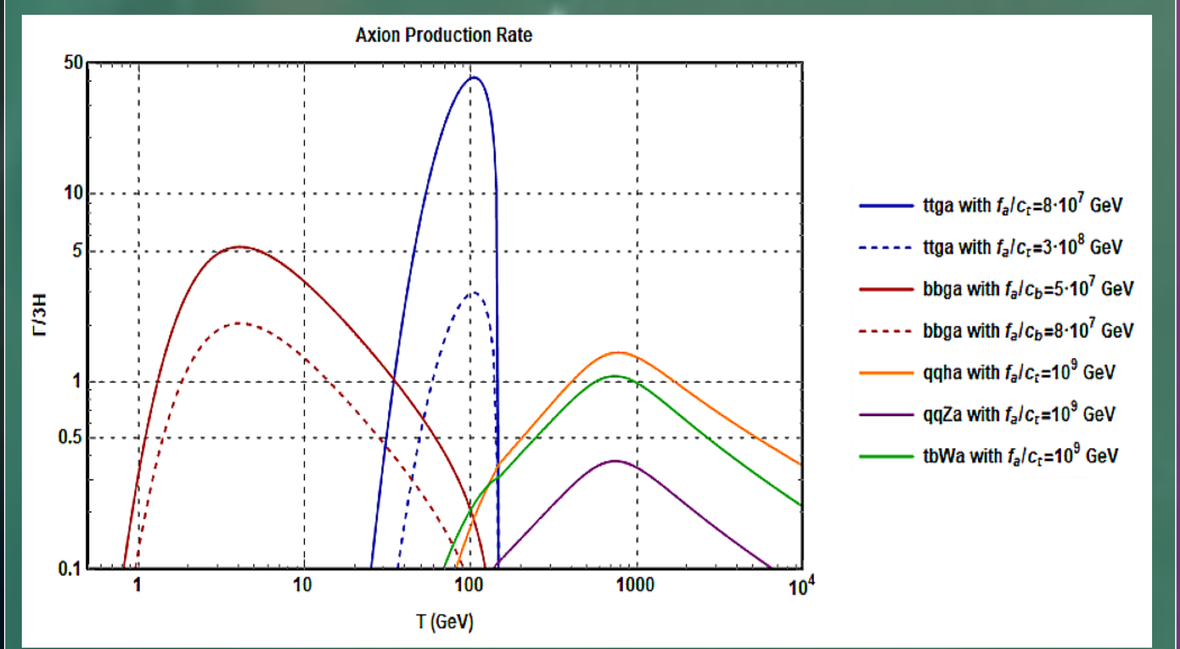
- Coupling to electrons (Astrophysics)

$$f_a \gtrsim 3{,}5 \cdot 10^9 \text{ GeV } for\ m_a \lesssim 1 \text{ eV}$$

- Coupling to photons (Astrophysics)

$$f_a \gtrsim 2{,}8 \cdot 10^8 \text{ GeV } for\ 1 \text{ eV} \lesssim m_a \lesssim 10 \text{ eV}$$

$$f_a \gg 2{,}8 \cdot 10^{10} \text{ GeV } for\ 10 \text{ eV} \lesssim m_a \lesssim 0{,}1 \text{ GeV}$$



ALP

- Coupling to W bosons (Flavour)

$$f_a \gtrsim 10^5 \text{ GeV } for\ 0{,}1 \text{ GeV} \lesssim m_a \lesssim 0{,}2 \text{ GeV}$$

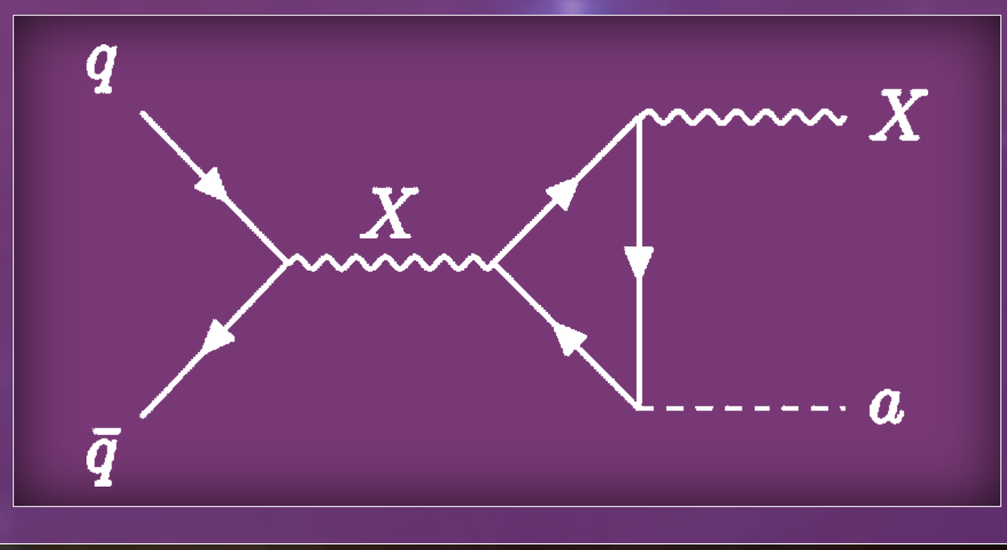
$$f_a \gtrsim 3{,}1 \cdot 10^2 \text{ GeV } for\ 1 \text{ GeV} \lesssim m_a \lesssim 5 \text{ GeV}$$

- Coupling to W bosons (Collider)

$$f_a \gtrsim 6{,}3 \cdot 10^4 \text{ GeV } for\ 0{,}2 \text{ GeV} \lesssim m_a \lesssim 1 \text{ GeV}$$

- If $c_{aWW} = 0$, Coupling to Z bosons (Collider)

$$f_a \gtrsim 2{,}6 \cdot 10^4 \text{ GeV } for\ 0{,}1 \text{ GeV} \lesssim m_a \lesssim 1 \text{ GeV}$$



References: [1] R. Peccei and H. Quinn. Physical Review Letters, 38(25):1440, 1977. [2] G. D'Ambrosio, et al. Nuclear Physics B, 645(1):155 – 187, 2002. [3] C. Froggatt and H. Nielsen. Nuclear Physics B, 147(3-4):277–298, 1979.