Chasing the MFVA: Axion Dark Radiation vs ALP at Colliders and Flavour Factories

UAM Universidad Autónoma de Madrid

ift Instituto de Física Teórica UAM-CSIC

invisiblesPlus

Fernando Arias-Aragón, fernando.arias@uam.es

Based on: FAA, L. Merlo, The Minimal Flavour Violating Axion, 1709.07039

FAA, F. D'Eramo, L. Merlo, A. Notari, R. Zambujal-Ferreira; to appear

WHERE TO LOOK FOR IT

Axion Dark Radiation → N_{eff}

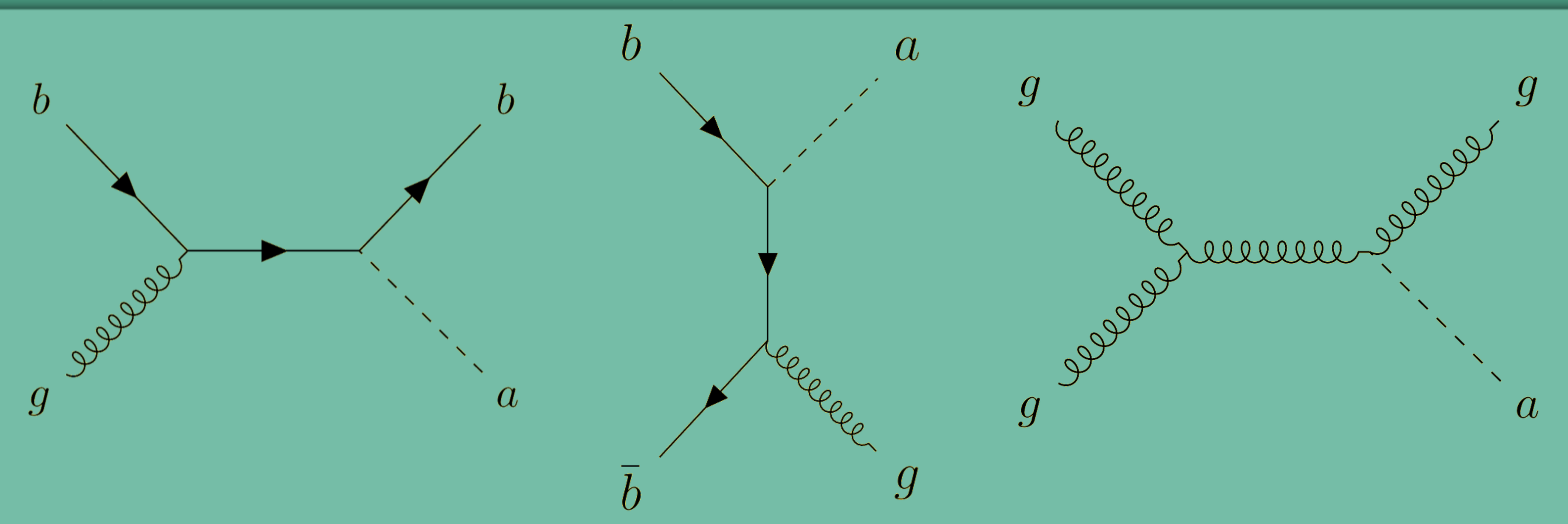
- Coupling to electrons (Astrophysics)

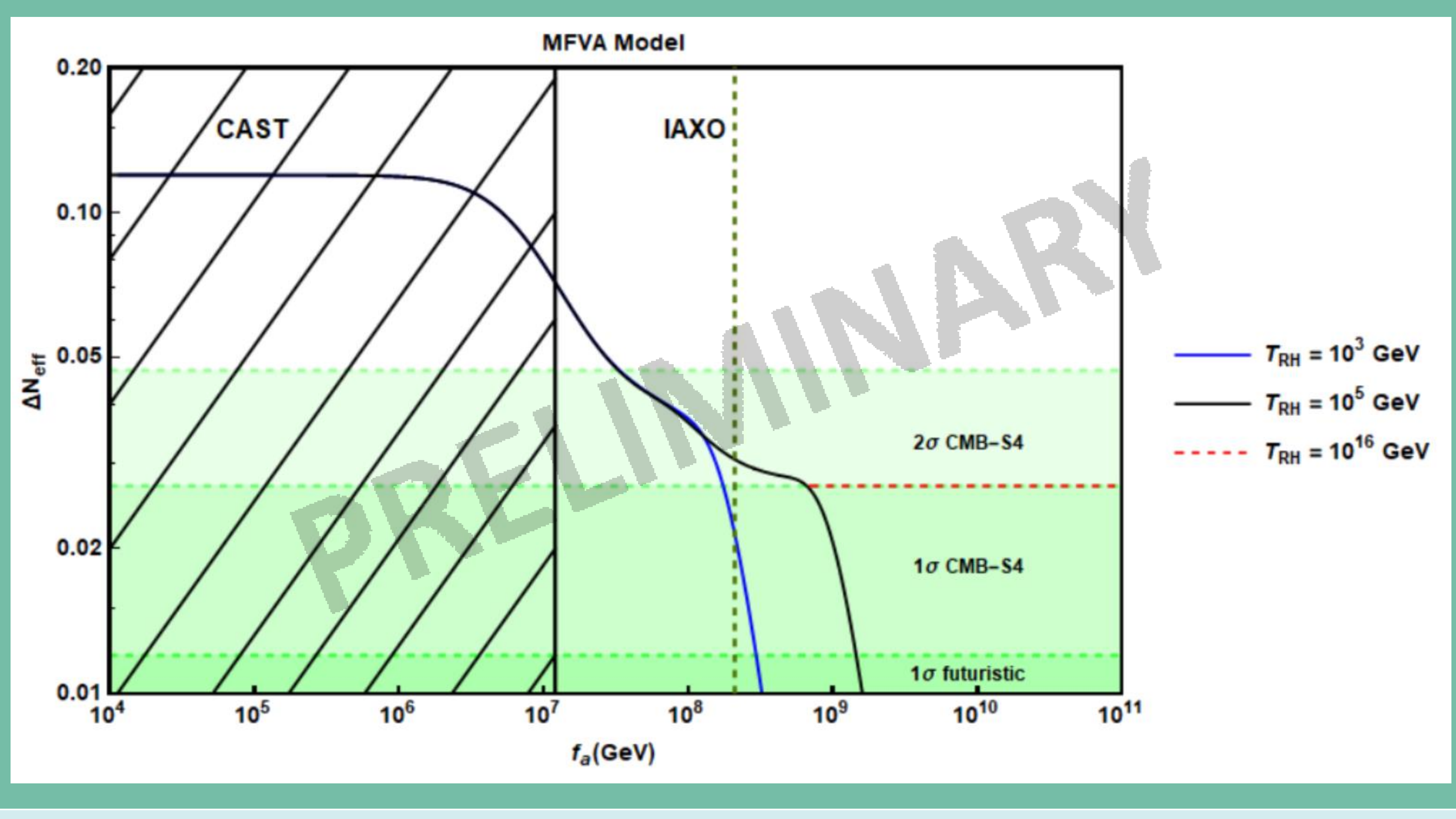
$$f_a \gtrsim 3{,}9 \cdot 10^8 \text{ GeV } for\ m_a \lesssim 1 \text{ eV}$$

- Coupling to photons (Astrophysics)

$$f_a \gtrsim 8{,}6 \cdot 10^6 \text{ GeV } for\ 10 \text{ meV} \lesssim m_a \lesssim 10 \text{ eV}$$

$$f_a \gg 8{,}6 \cdot 10^8 \text{ GeV } for\ 10 \text{ eV} \lesssim m_a \lesssim 0{,}1 \text{ GeV}$$





ALP → signals in Colliders & Flavour Physics

- Coupling to W bosons (Flavour)

$$f_a \gtrsim 3{,}5 \cdot 10^3 \text{ GeV } for\ 0{,}1 \text{ GeV} \lesssim m_a \lesssim 0{,}2 \text{ GeV}$$

$$f_a \gtrsim 105 \text{ GeV } for\ 0{,}2 \text{ GeV} \lesssim m_a \lesssim 5 \text{ GeV}$$

- Coupling to bottom (Flavour)

$$f_a \gtrsim 830 \text{ GeV } for\ m_a \sim 1 \text{ GeV}$$

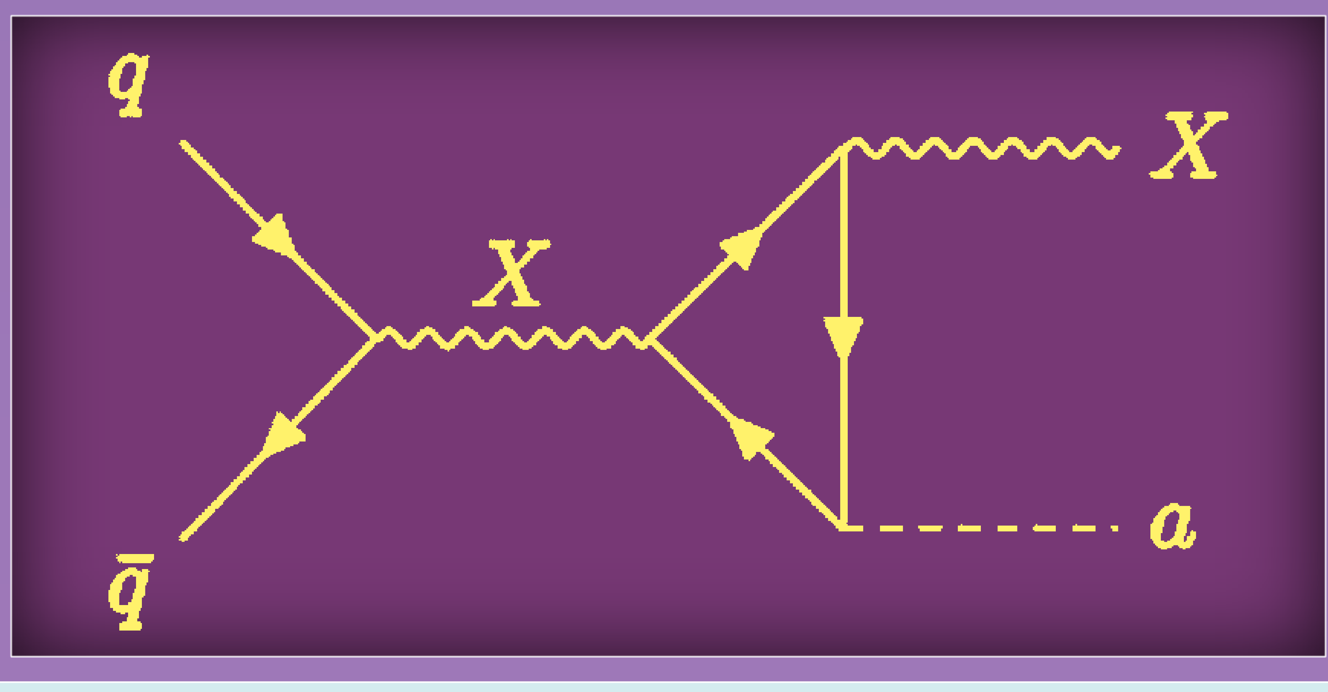
- Coupling to W bosons (Collider)

$$f_a \gtrsim 6{,}5 \text{ GeV } for\ 0{,}2 \text{ GeV} \lesssim m_a \lesssim 1 \text{ GeV}$$

- Coupling to Z bosons (Collider)

$$f_a \gtrsim 5{,}8 \text{ GeV } for\ 0{,}1 \text{ GeV} \lesssim m_a \lesssim 1 \text{ GeV}$$

ALP scale well below that of other models like Axiflavon[1]/Flaxion[2]!



THE MODEL

- PQ symmetry identified within the MFV [3] 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 [4]) makes Yukawas invariant under PQ
- Yukawas are spurions under the non-Abelian symmetries

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

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

WHAT IS ACHIEVED WITH THIS MODEL

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

- Natural origin for the PQ Symmetry from flavour ✓
- Strong CP Problem [5] + BSM Flavour Problem ✓
- DM + detection through N_{eff} ✓

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

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

References: [1] L. Calibbi, F. Goertz, D. Redigolo, R. Ziegler, and J. Zupan, PRD 95, 095009 (2017) [2] Y. Ema, K. Hamaguchi, T. Moroi, and K. Nakayama, JHEP 01, 096 (2017) [3] G. D'Ambrosio, et al. NPB, 645(1):155 – 187, 2002. [4] C. Froggatt and H. Nielsen. NPB, 147(3-4):277–298, 1979. [5] R. Peccei and H. Quinn. PRL, 38(25):1440, 1977.