ALPS DARK MATTER DETECTION

Andrea Caputo

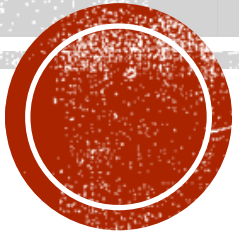
Based on

A.C, M.Regis, M.Taoso, S.J Witte **JCAP 1903 (2019) no.03, 027**

A.C, L. Sberna, M. Frias, D.Blas, P.Pani, L. Shao and W.Yan arXiv 1902.02695

Invisible19 Workshop

June 2019, Valencia



IFIC INSTITUT DE FÍSICA CORPUSCULAR

VNIVERSITAT DE VALÈNCIA

elusives neutrinos, dark matter & dark energy physics

THE STRONG CP PROBLEM

We know that QCD suffers from the fact one can add to the Lagrangian the following term

$$\mathcal{L} \supset -\theta \frac{g^2}{16\pi} Tr(G\tilde{G})$$

$$G_{\mu\nu} = G^a_{\mu\nu} T^a$$

$$\tilde{G}_{\mu\nu} = \epsilon_{\mu\nu\varrho\sigma} G^{\varrho\sigma}$$

It can be shown that this term is a *total derivate* and one would naively think we can just forget about it. However, the structure of QCD vacuum makes this term important, with physical consequences

It leads to a dipole moment for the neutron

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$$\theta < 10^{-10}$$

THE AXION

The idea is to assume a spontaneously broken U(1) PQ symmetry: theta becomes the goldstone boson field

$$\mathcal{L} \supset -\frac{a(x)}{f_a}\frac{g^2}{16\pi}Tr(G\tilde{G})$$

Good dark matter candidate

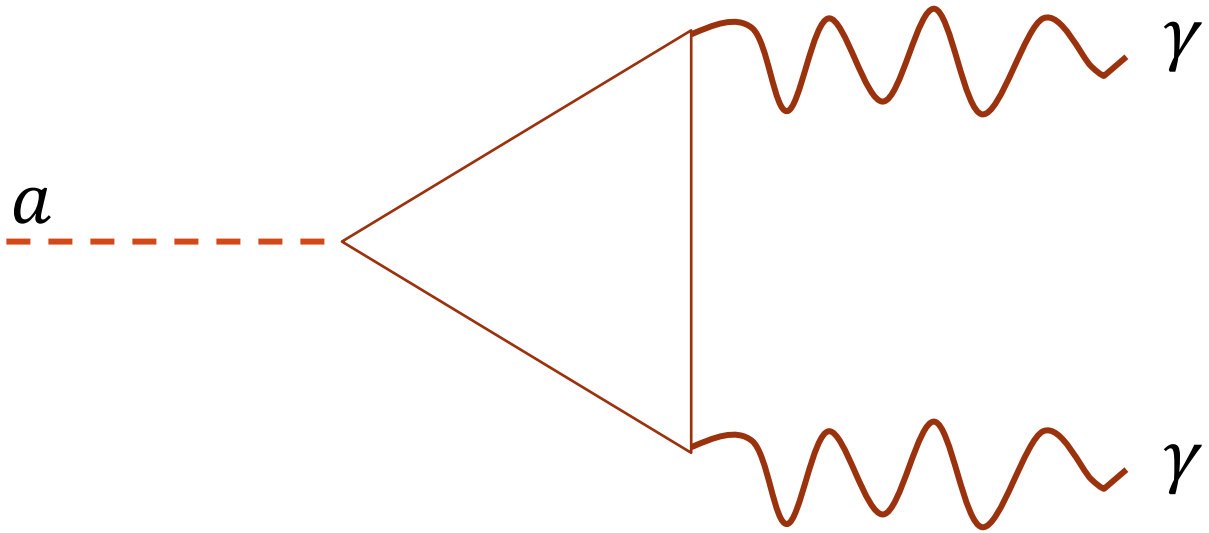
Performing a *chiral* (and *anomalous*) transformation one also gets a very important interaction

$$\mathcal{L} \supset -\frac{a(x)}{f_a}\frac{\alpha}{2\pi}F\tilde{F}$$

AXION DECAY

AC, Carlos Peña Garay and Samuel J.Witte, ***Phys.Rev. D98 (2018) no.8, 083024***

AC, Marco Regis, Marco Taoso, Samuel J.Witte, **JCAP 1903 (2019) no.03, 027**

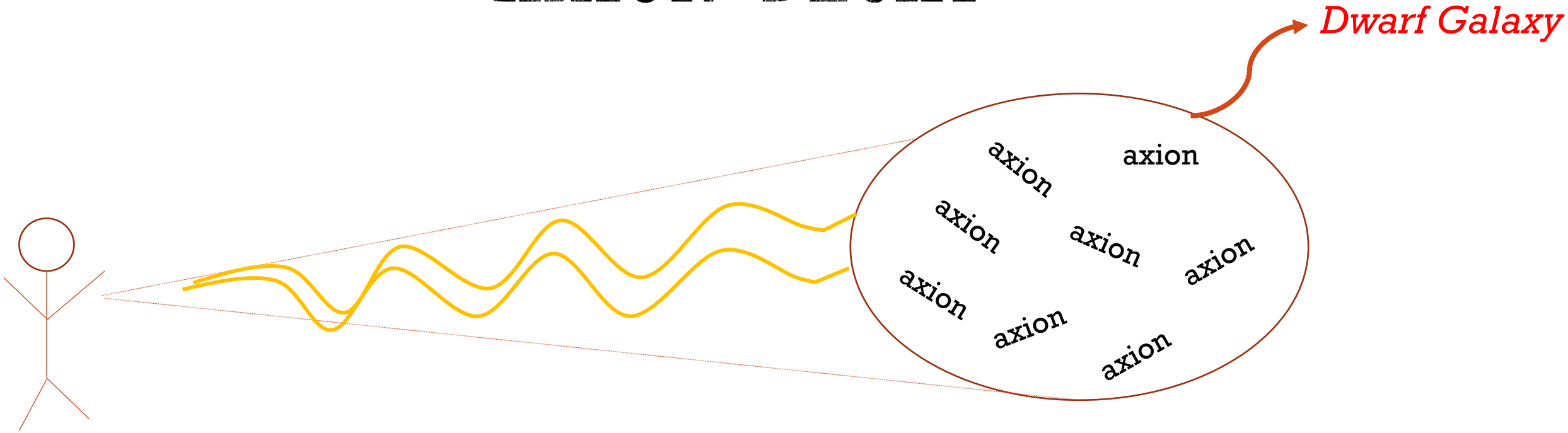


$$\tau_a \sim \frac{1}{m_a{}^3 g_{a\gamma\gamma}{}^2}$$

$$m_a = 10^{-6} eV$$
$$g_{a\gamma\gamma} = 10^{-10} GeV^{-1}$$

$$\tau_a \sim 10^{32} years$$

AXION DECAY



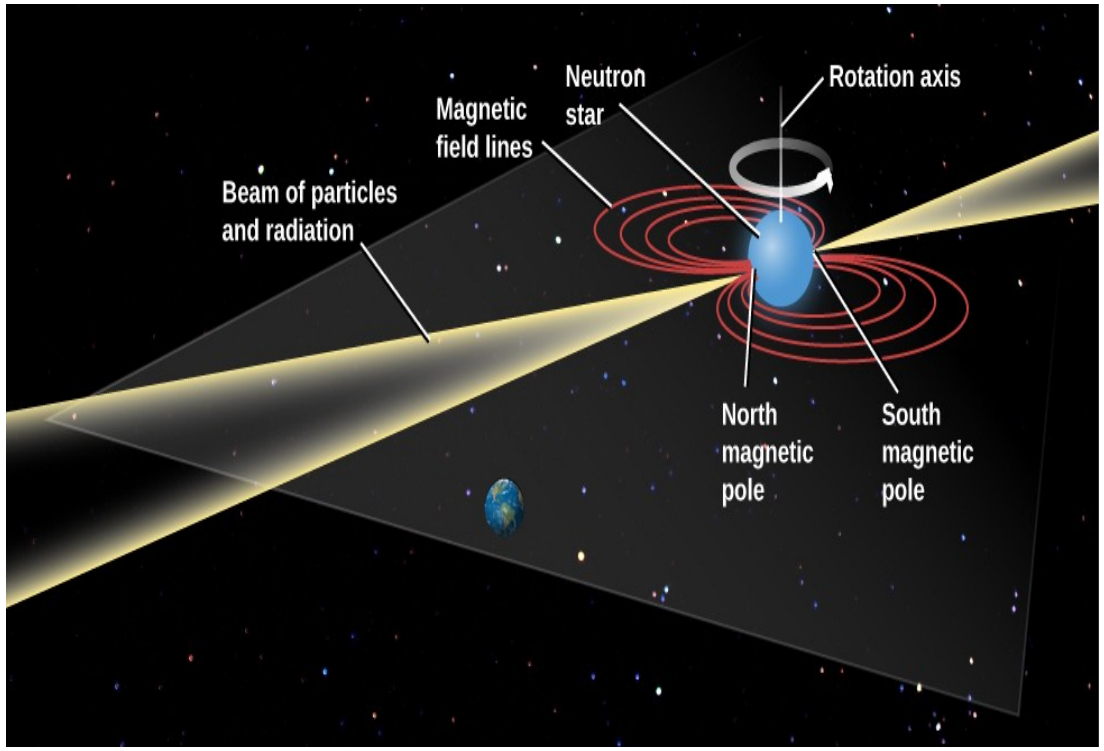
$$S_{decay} = \frac{\Gamma_a}{4\pi\Delta\nu} \int dl d\Omega \rho_a(l, \Omega) \left(1 + 2 f_\gamma(l, \Omega)\right)$$

Observable: photons with

$$E_\gamma = \frac{m_a}{2}$$

$$\nu = \frac{m_a}{4\pi}$$

PULSAR POLARIZATION MEASUREMENTS



Modified Maxwell Equations

$$\partial_\mu F^{\mu\nu} + \frac{1}{2} g_{a\gamma\gamma} \epsilon^{\mu\nu\alpha\beta} \partial_\mu \left(a F_{\alpha\beta} \right) = 0$$

Dispersion relations are modified → $\omega_\pm = k \pm g_{a\gamma\gamma} \partial_0 a(t)$

$$with \quad a(t) \sim a_0 \cos(m_a t + \delta)$$

Due to *parity violation* photons with different chiralities propagate at different speed. Given a polarized signal this induces a *rotation of the polarization angle*

$$\theta_{pol} \sim 1.4 \cdot 10^{-2} \sin(m_a t + \delta) \frac{g_{a\gamma\gamma}}{10^{-12} GeV^{-1}} \frac{10^{-22} eV}{m_a}$$

THANKS FOR THE ATTENTION!

This project has received funding/support from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 674896