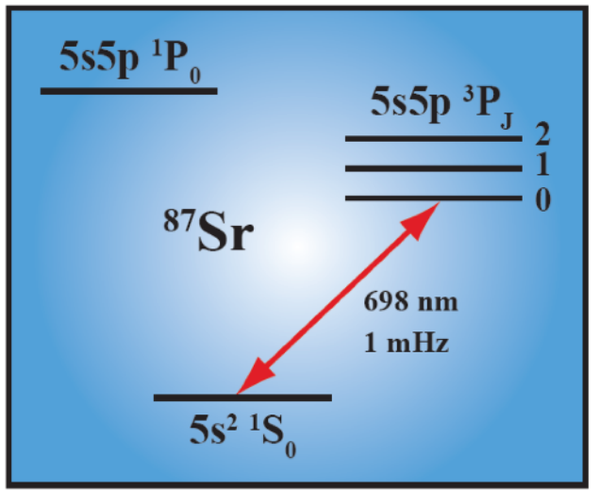
Dark Matter Detection with MAGIS

Arvanitaki, PWG, Hogan, Rajendran, Tilburg, PRD **97** (2018)

MAGIS could also detect ultralight dark matter (e.g. axions)

such DM acts like a field, can oscillate fundamental 'constants' e.g. electron mass

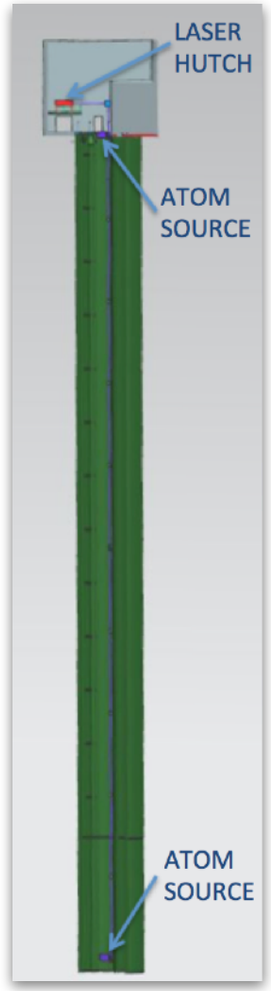


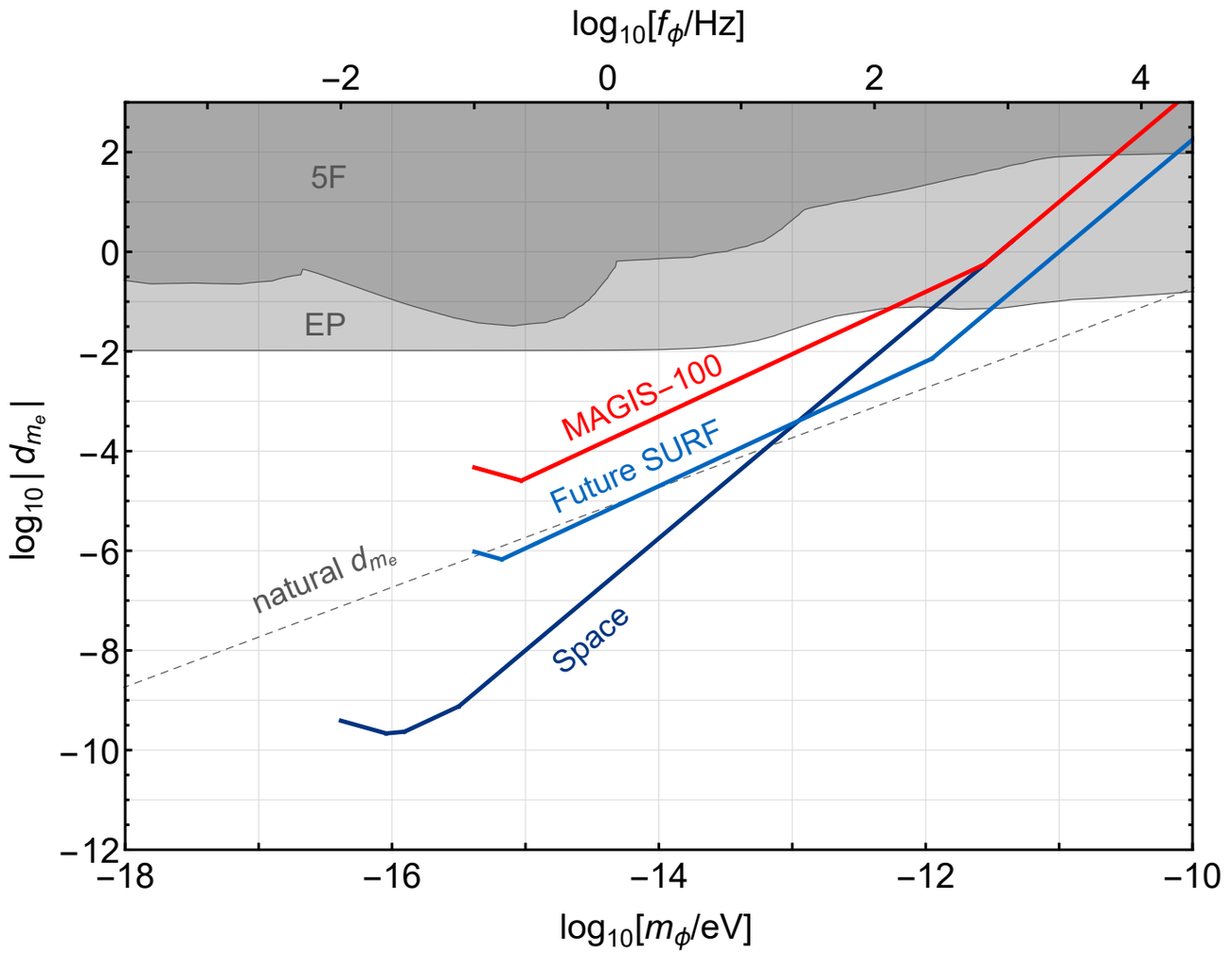
Clock transition in candidate atom ^{87}Sr

energy splitting will oscillate with fixed frequency

only observable if compare two clocks ➜ GW detector

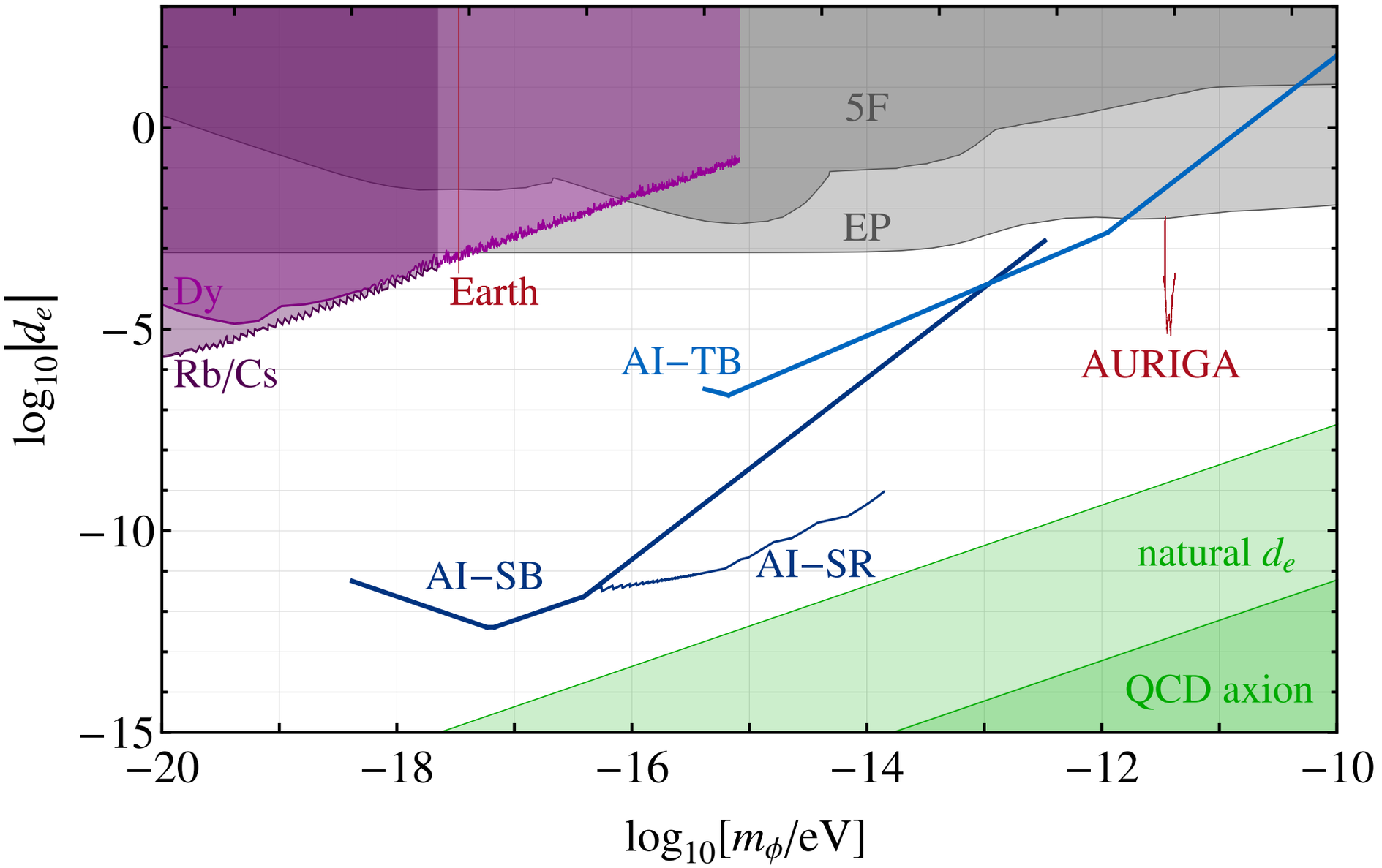
not observable in laser interferometer GW detector





Atomic Clock Detection of DM

Arvanitaki, Huang, Van Tilburg, PRD **91** (2015)



1606.04541

Dark Matter Detection with MAGIS

MAGIS can also detect ultralight dark matter (e.g. axions) with 3 complementary searches:

1. single-baseline "gravitational wave" search

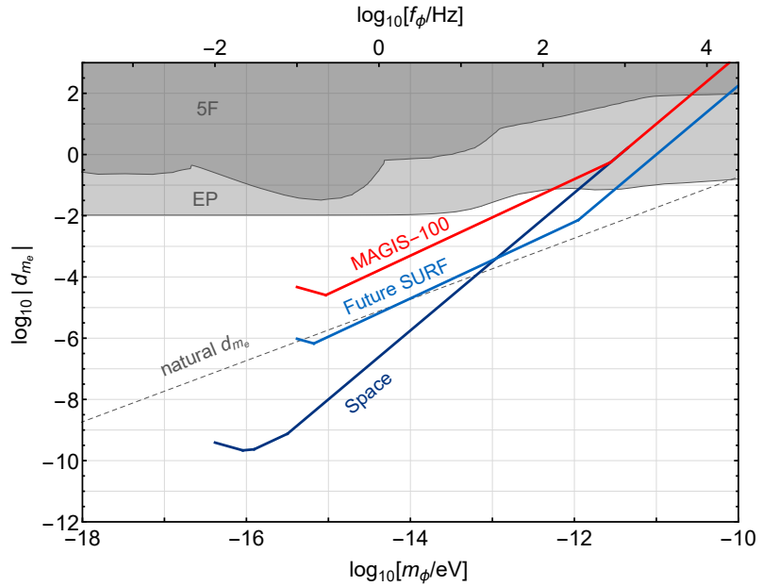
   Arvanitaki, PWG, Hogan, Rajendran, Tilburg, PRD **97** (2018)

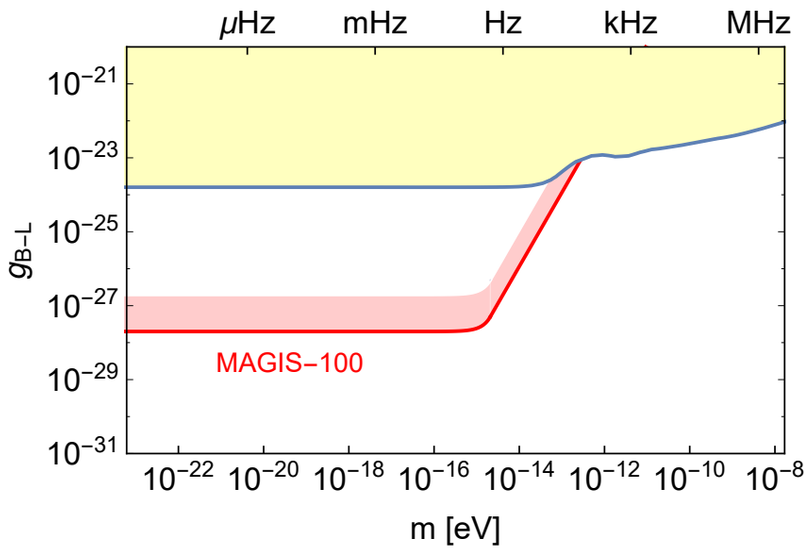
2. equivalence principle violation search

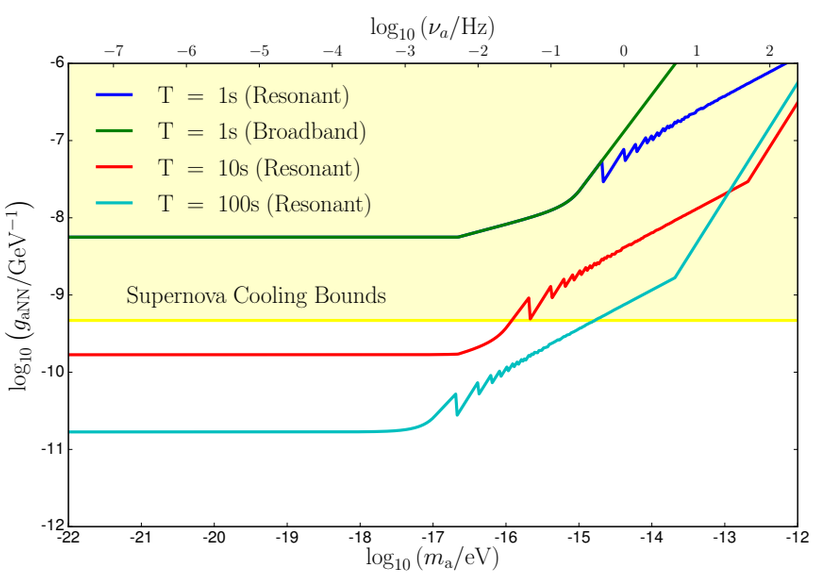
   PWG, Kaplan, Mardon, Rajendran, Terrano, PRD **93** (2016)

3. spin torque search

   PWG, Kaplan, Mardon, Rajendran, Terrano, Trahms, Wilkason, PRD **97** (2018)

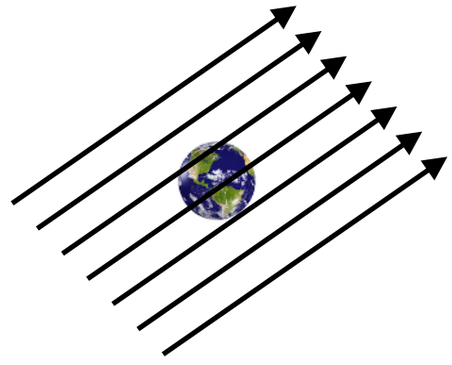






Force/Torque from Dark Matter

PRD **93** (2016) arXiv:1512.06165



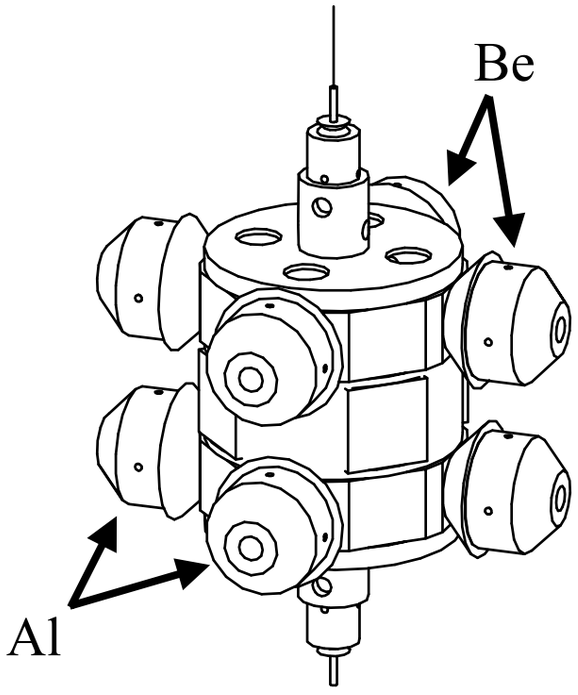
New oscillatory force/torque from dark matter

New Direct Detection Experiments:

Torsion Balances

scalar balance for force

spin-polarized for torque

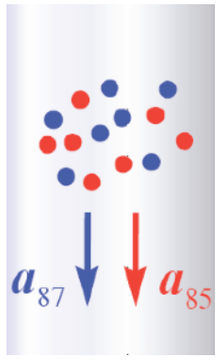


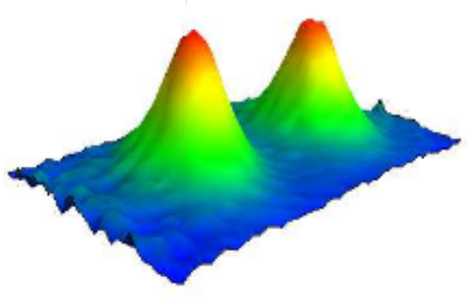
Atom Interferometers

split + recombine atom wavefunction

measure atom spin and acceleration

^{85}Rb-^{87}Rb

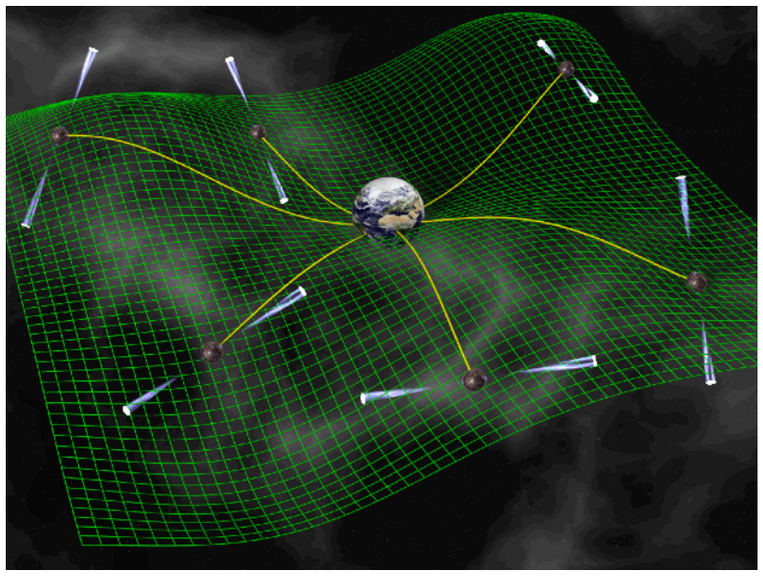




Pulsar Timing Arrays

DM and gravitational wave

detection similar



Eot-Wash analysis underway

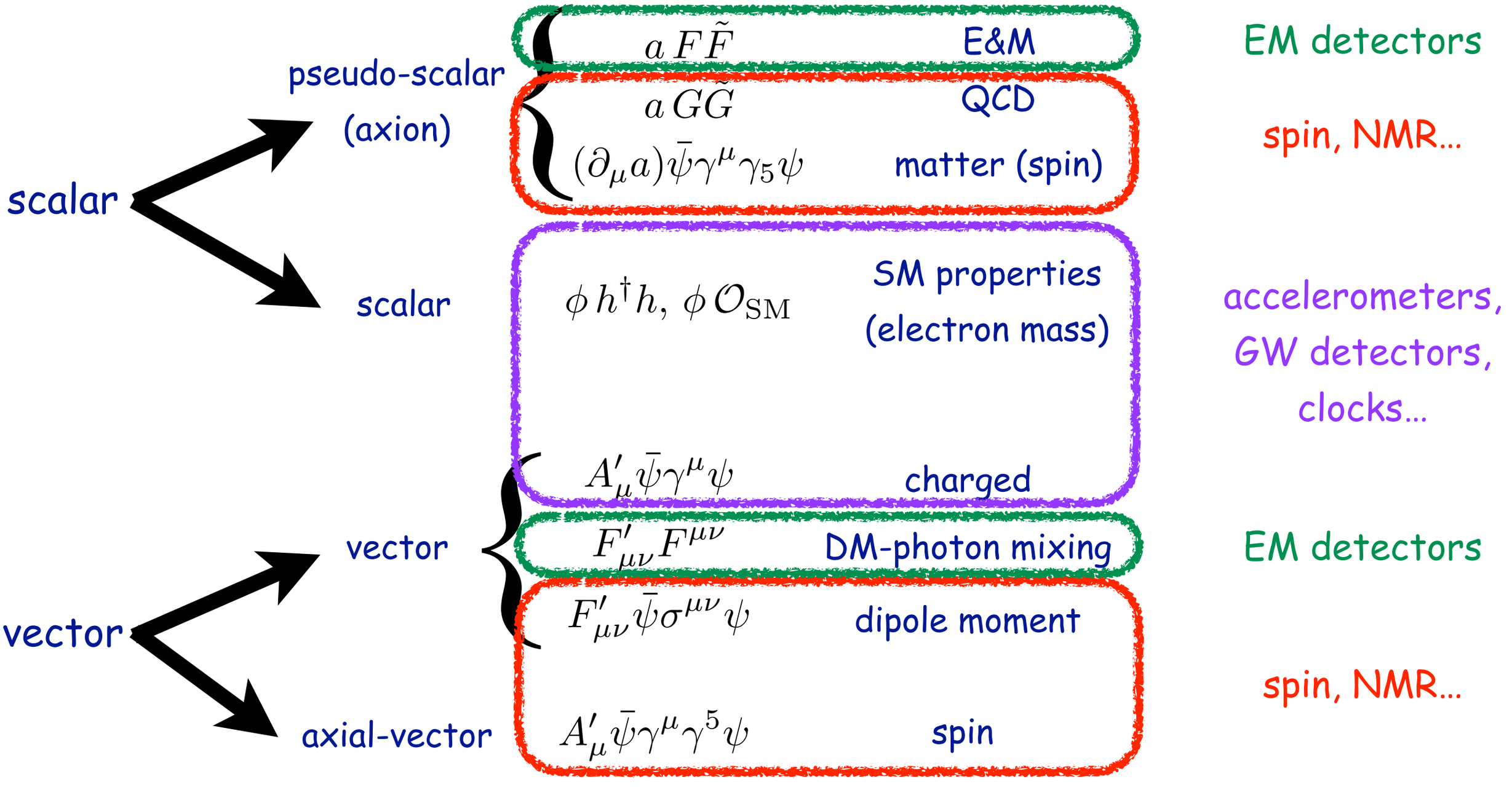
with Will Terrano

In construction Kasevich/Hogan groups

ultralight DM and gravitational wave detection similar!

Possibilities for Light Dark Matter

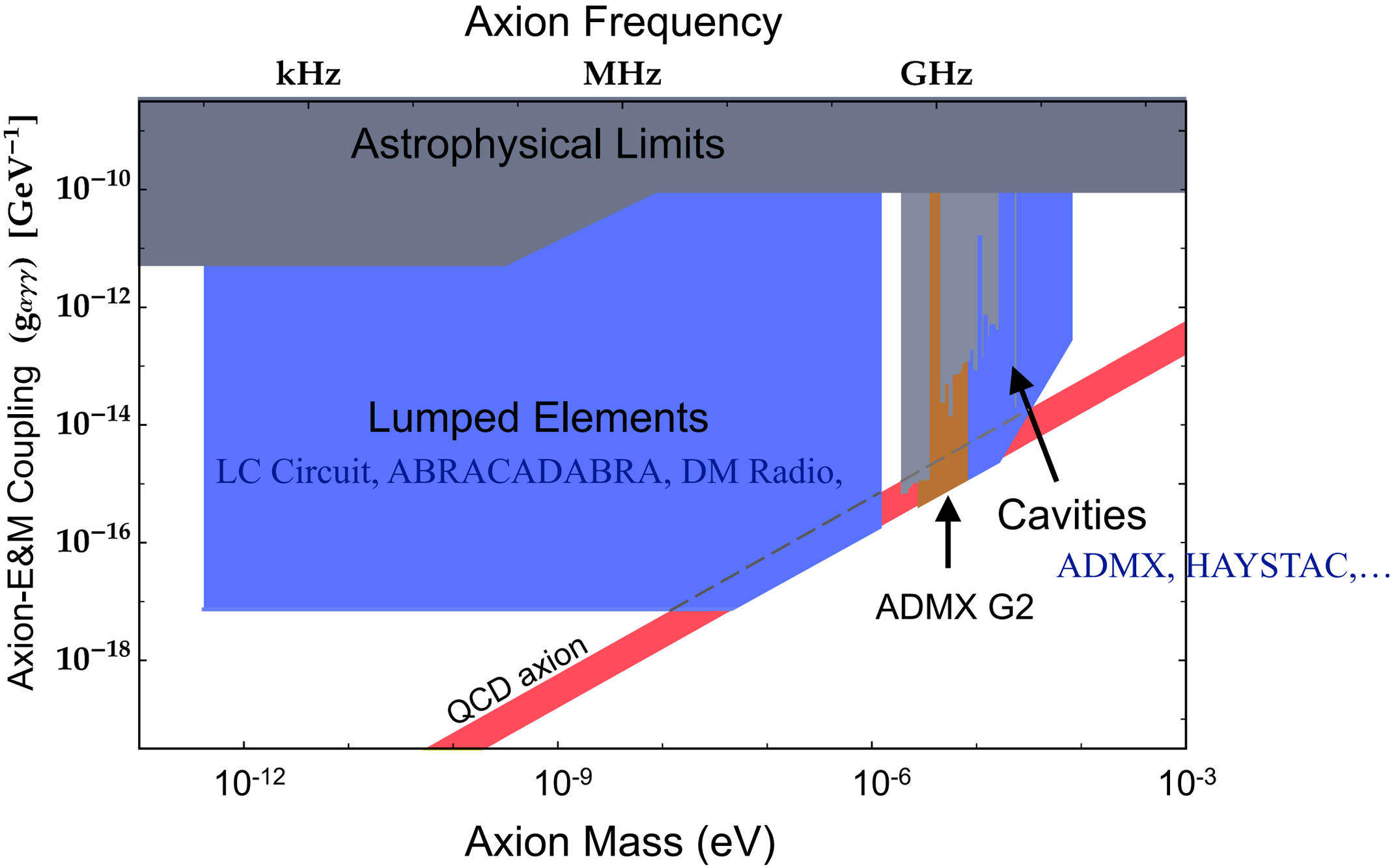
All UV theories summarized by only a few possibilities
(symmetry, effective field theory):



Can cover all these possibilities!

arXiv:1512.06165

Electromagnetic Axion DM Detection

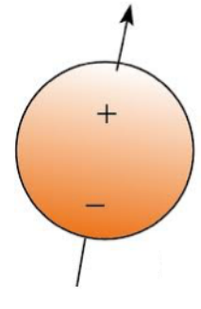


The Axion

how cover the full axion mass range? a new type of coupling

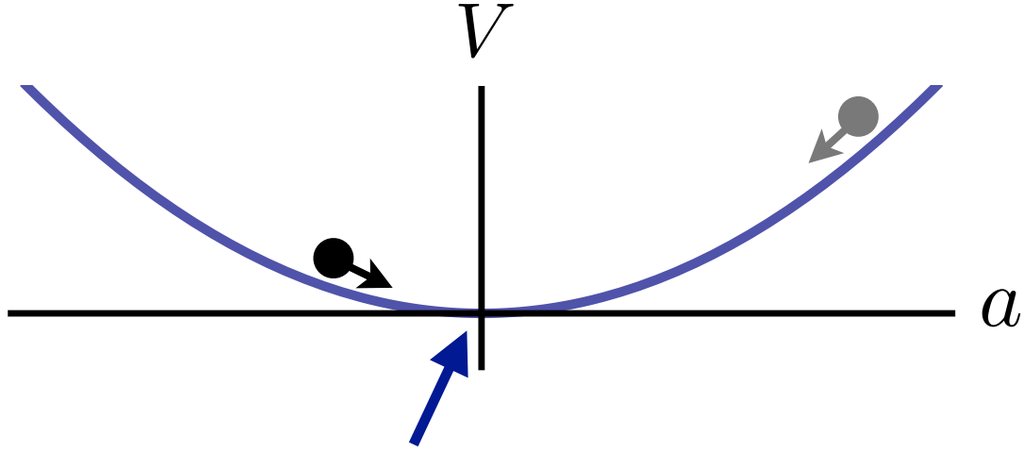
Strong CP problem:

$\mathcal{L} \supset \theta\, G\widetilde{G}$ creates nucleon EDM $d \sim 3 \times 10^{-16}\, \theta\, e\,\mathrm{cm}$ measurements ➜ $\theta \lesssim 10^{-9}$



Axion solution:

make it dynamical $\mathcal{L} \supset \dfrac{a}{f_a} G\widetilde{G}$ so damps down towards zero

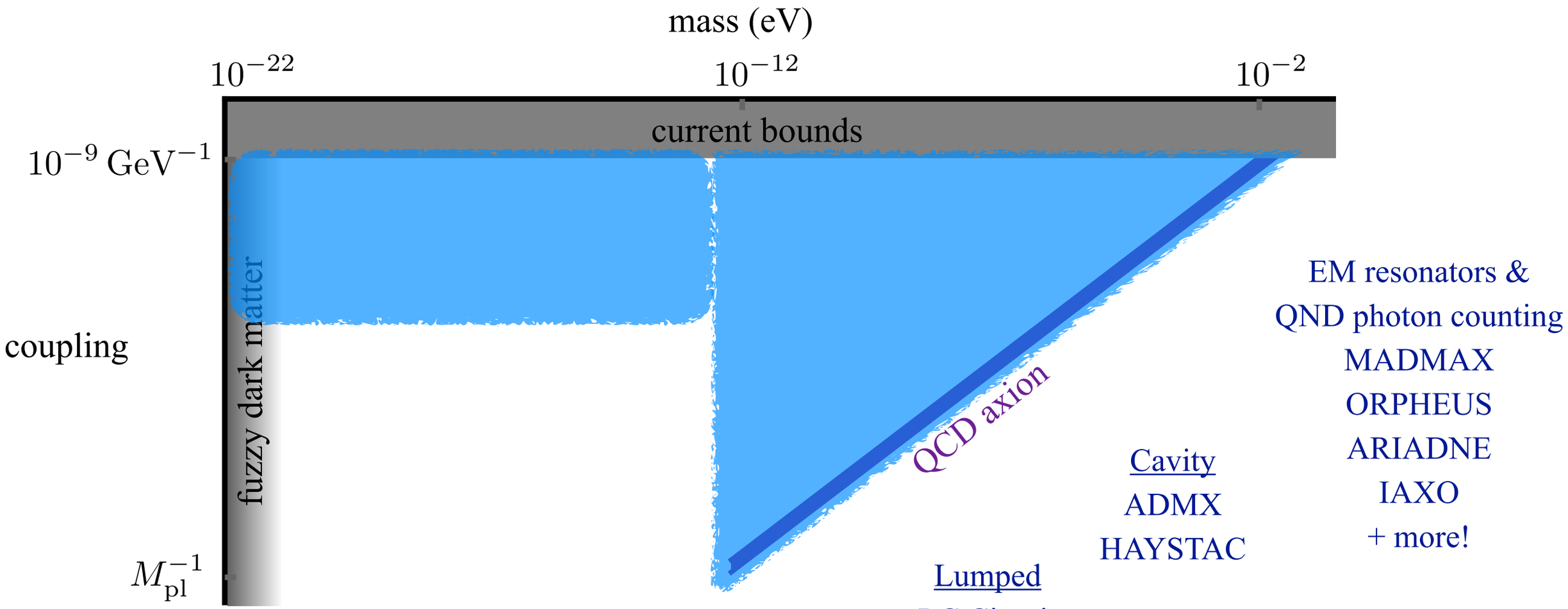


$$a(t) \sim a_0 \cos\left(m_a t\right)$$

still has small residual oscillations today ➜ Axion is a natural dark matter candidate

Preskill, Wise & Wilczek, Abott & Sikivie, Dine & Fischler (1983)

Ultralight Dark Matter Detection



Cover entire QCD axion

+ broad general axion (& dark photon) parameter space ~20 orders of magnitude in mass

likely more good ideas out there!