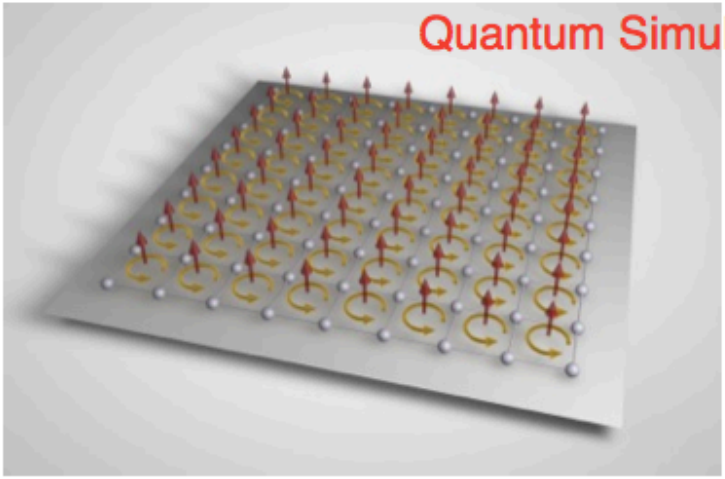
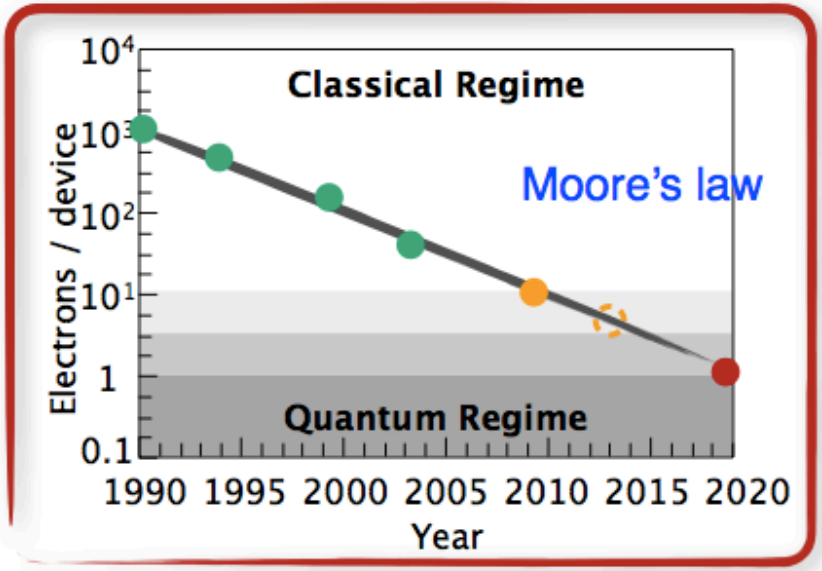
Quantum Simulations

- Lattice Gauge Theories
- Quantum Technologies
- Role of European and Italian collaborations





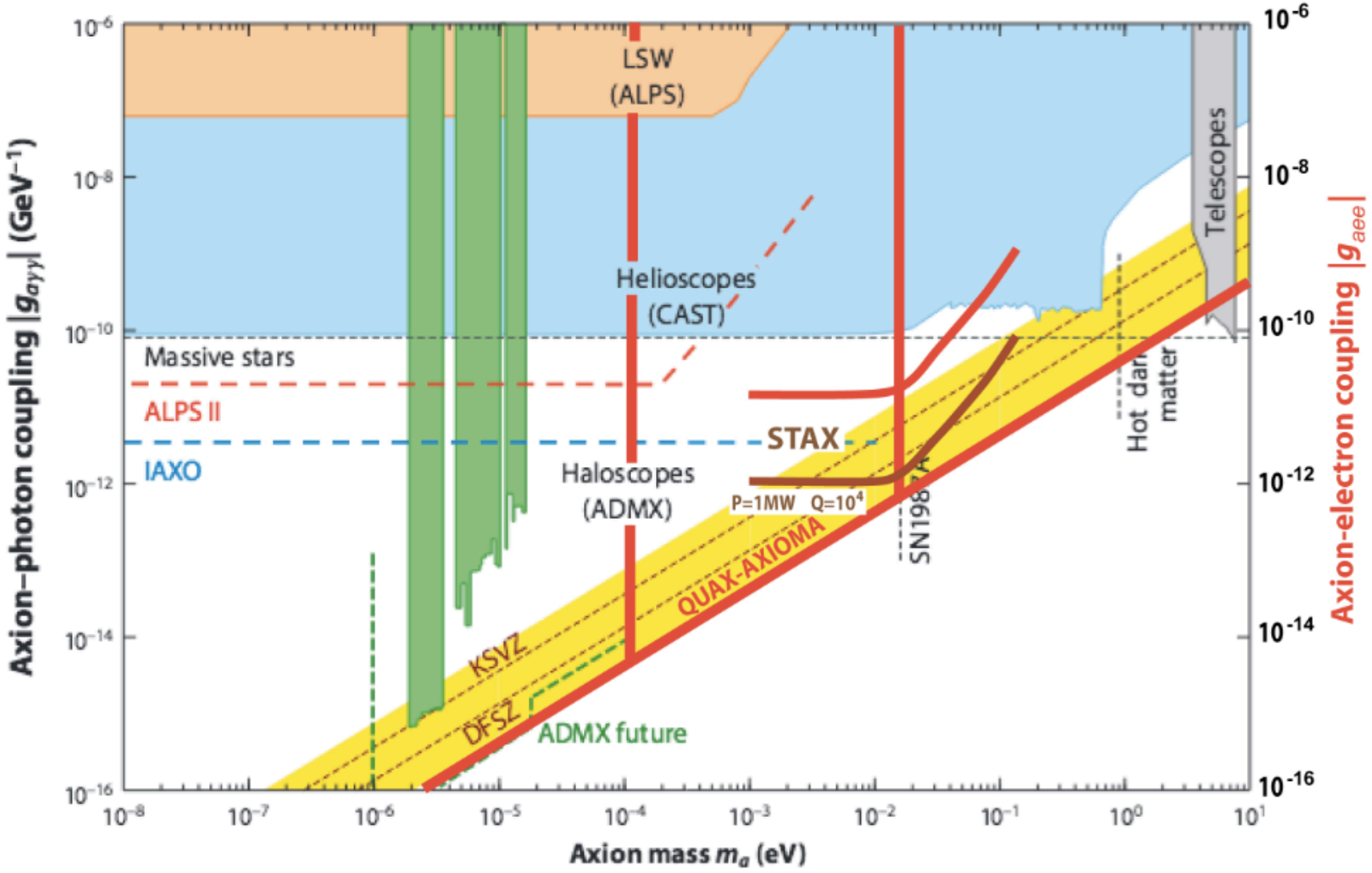
Topics to discuss

- Quantum Metrology
- Quantum Imaging
- Quantum Communication
- Spintronics
- Photonics
- Quantum Opto-Mechanics

Fundamental Physics & New Connections

- Cosmological Axions & ALPS
- Experimental Gravitational
- Nuclear Clock based on Isomeric Nuclear States
- Dark Energy : Frequency Comb & NIR TES

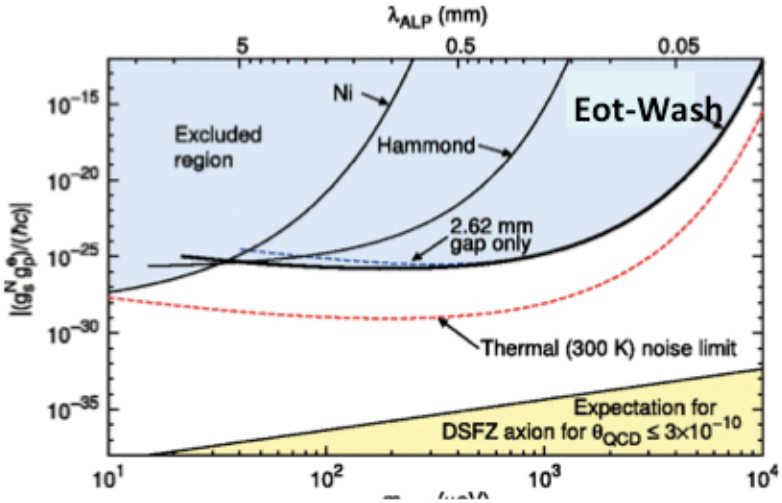
Experimental Searches for the Axion and Axion-Like Particles



Gravitational and Fundamental Physics Items

Axion like bosons with scalar coupling gs search via monopole-dipole interacion

$$V_{\rm md} = \frac{\hbar g_{\rm s} g_{\rm p}}{8\pi m_e c}\left[(\hat{\boldsymbol{\sigma}}\cdot\hat{r})\left(\frac{1}{r\lambda}+\frac{1}{r^2}\right)\right]e^{-r/\lambda}$$

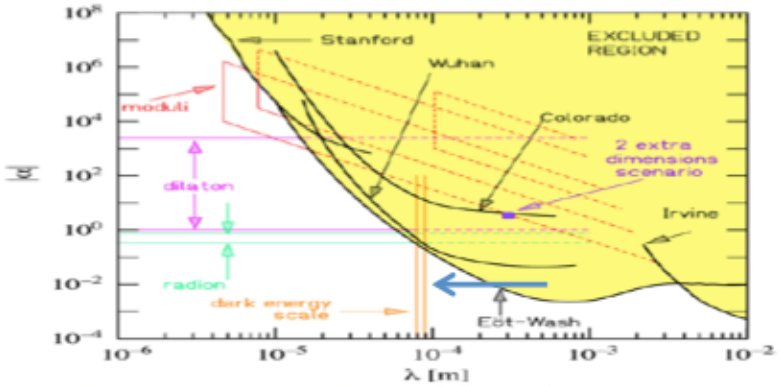


Newton Law at small distances :

$$V(r) = -G_N\frac{m_1 m_2}{r}(1+\alpha e^{-r/\lambda})$$

Extra dimensions tens microns size

Chamelons



Quantum field and gravitation:

$$\vec{F} = \frac{\pi^2 L^2 \hbar c}{720 a^3}\frac{g}{c^2}\vec{e}_r$$

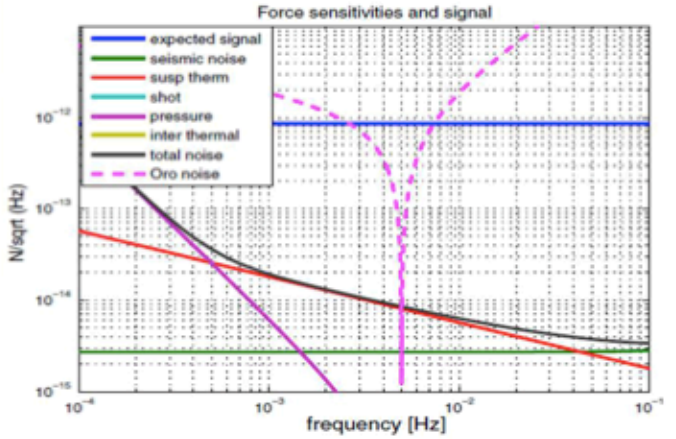
Quantum systems and gravitational effect

Vacuum fluctuations and gravity

Spin-gravity coupling

Quantum gravity and Lagrangian points

MONITOT

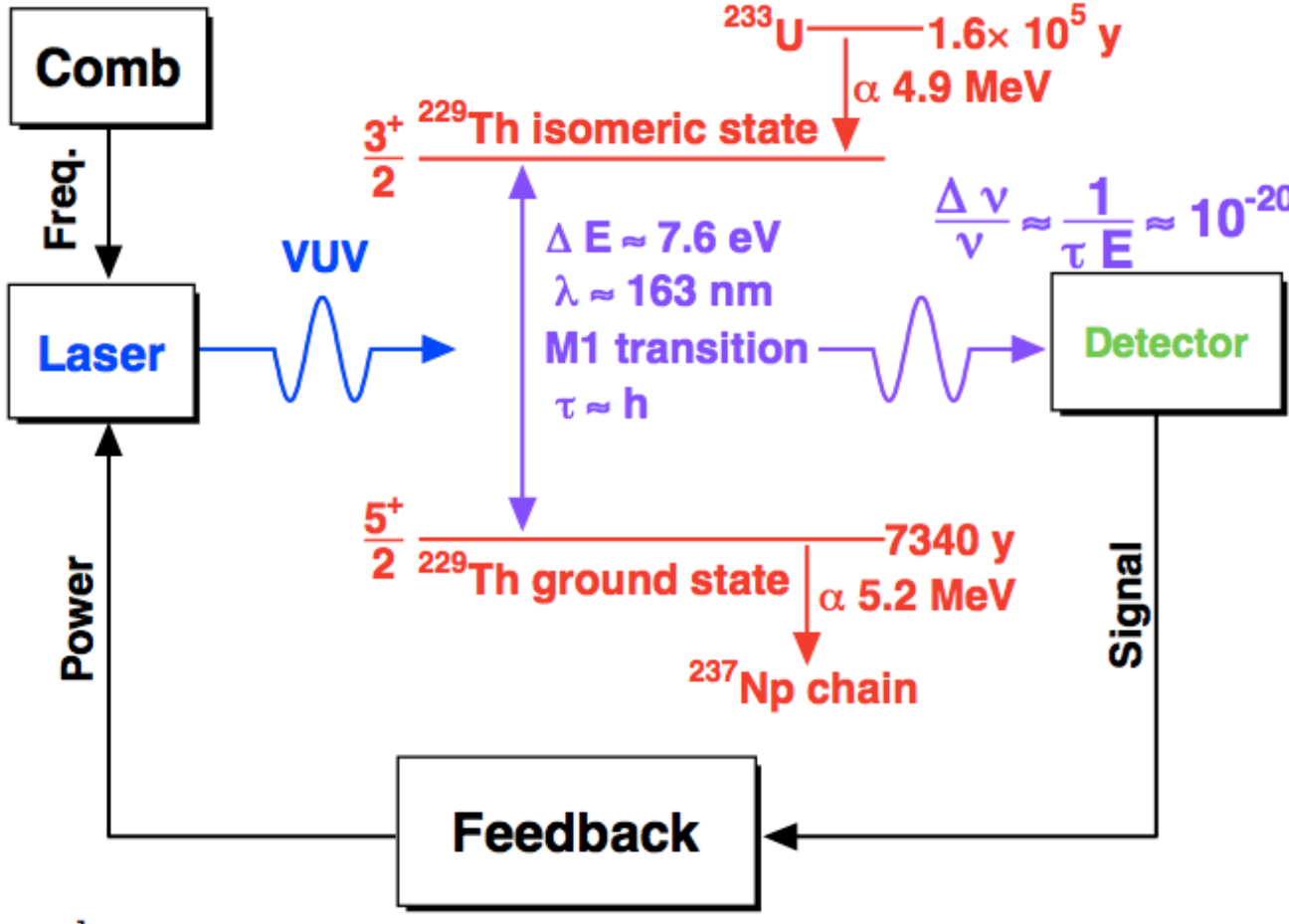


^{229}Th-based Nuclear Clock

1. Lowest nuclear exited state[1],
2. only indirect observation[2],
3. VUV-laser excitation,
4. very narrow linewidth[3],
5. $N=10^5 \div 10^{12}$ oscillators[4,5],

$$FoM = \frac{\nu\sqrt{N}}{\Delta\nu}.$$

6. Radiotherapy with ^{225}Ac,^{213}Bi decay prod.[6].



[1] L.Kroger and C.Reich, Nucl.Phys.A259, 29(1976).
[2] R.Beck et al., Phys.Rev.Lett.98, 142501 (2007).
[3] V.Strizhov and E.Tkalya, Sov.Phys.JETP 72, 387 (1991).
[4] C.Campbell et al., Phys.Rev.Lett.102, 233004 (2009).
[5] R.Jackson et al.,J.Phys.Cond.Mat.21, 325403 (2009).
[6] O.Couturier et al., Eur.J.Nucl.Med.Mol.Img.32, 601 (2005)

FREQUENCY COMB FOR NEW PHYSICS

- High resolution laser spectroscopy
  - testing QED
  - testing special relativity
  - determination of fundamental constants
  - detect or limit slow time evolution of these constants
- Optical atomic clocks
- Controlling the electric field transients of pulses
  - generation attosecond pulses
- Direct comb spectrocopy
  - high resolution XUV laser spectroscopy
- Calibration of astronomical spectrographs
  - detecting extra-solar planets
  - temporal evolution of constants on cosmological time scales
  - confirm or rule out existence of dark energy
  - solar gravitational red shift