Search for ultra-light scalar DM with atomic clocks

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A. Arvanitaki, JH, K. Van Tilberg [1405.2925]

on going experimental effort: D. Budker, N. Leefer…

Ultra-light Scalar DM

- Scalar Background Field $\phi(t) = A_\phi \sin[m_\phi t]$
  - Mass: $m_\phi \ll 1eV \ (10^{-22}eV \sim 10^{-8}eV)$
  - Amplitude: $A_\phi = \sqrt{\rho_\phi / m_\phi^2}$
  - Coherence Time: $\tau_\phi = \dfrac{1}{m_\phi v^2} \sim \dfrac{Q = 10^6}{m_\phi}$
- Coupling to SM

$$\mathscr{L} \supset \frac{1}{4e^2} F_{\mu\nu}F^{\mu\nu} + d_e \frac{\phi}{M_{\rm pl}} \frac{1}{4e^2} F_{\mu\nu}F^{\mu\nu}$$

$$\alpha = \alpha_0 \left[1 + d_e \kappa \phi(t)\right]$$

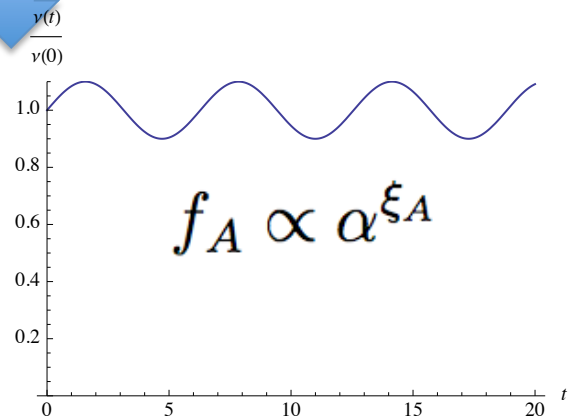
Signature

- Particle / Force mediator
  - Fifth force
  - Equivalence principle test
- Wave
  - Oscillation of clock frequency

Damour, Donoghue [1007.2790]

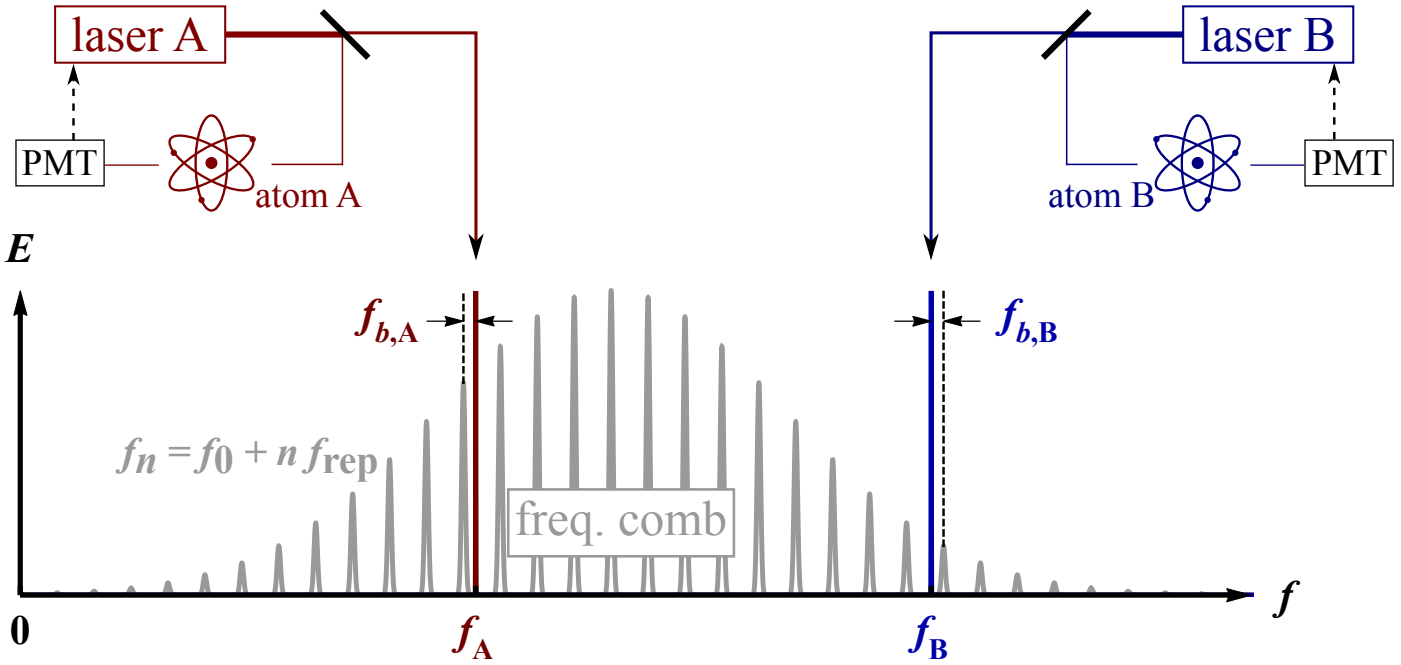
$$\alpha = \alpha_0 \left[1 + d_e \kappa \phi(t)\right] \qquad \phi(t) = A_\phi \sin[m_\phi t]$$

Oscillating fine structure constant



Experiment

- Idea: Compare two atomic clocks (10^{-18})



Preliminary Result