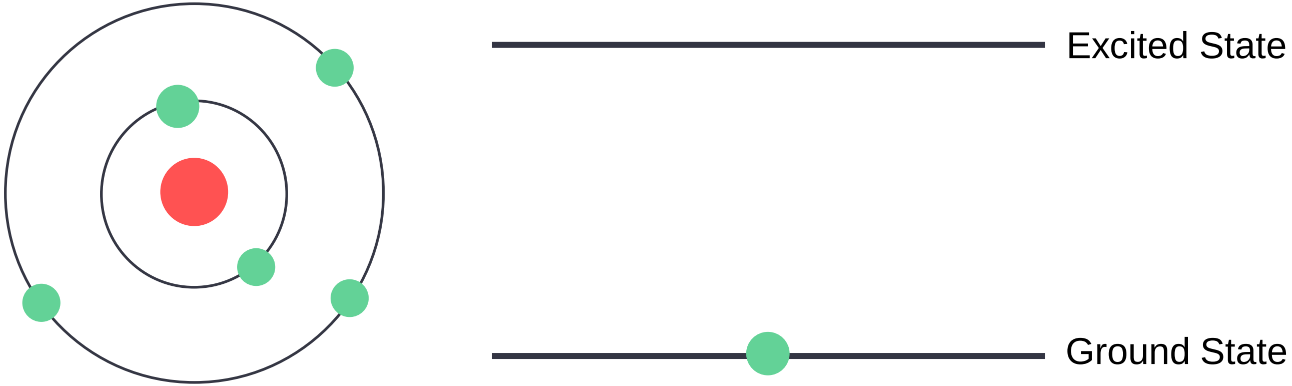
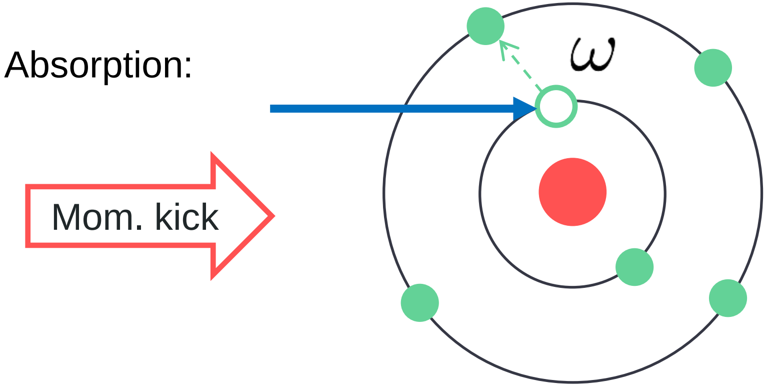
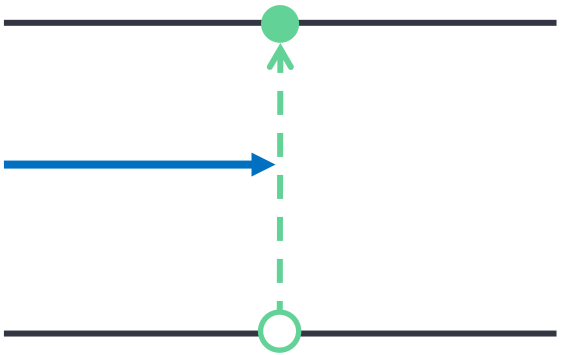
Consider a 2-level atom



Consider a 2-level atom

Photon Absorption:

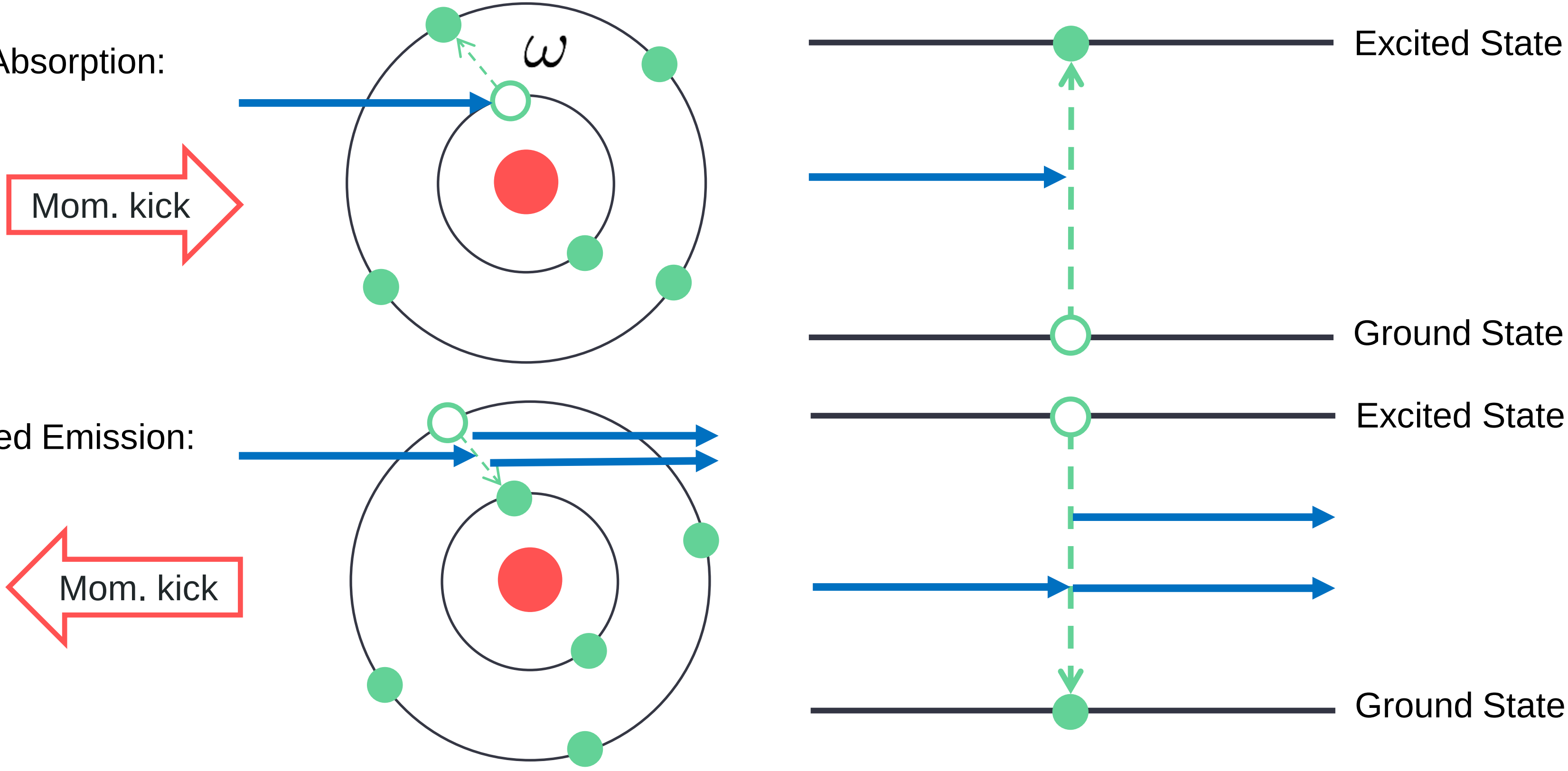




Consider a 2-level atom

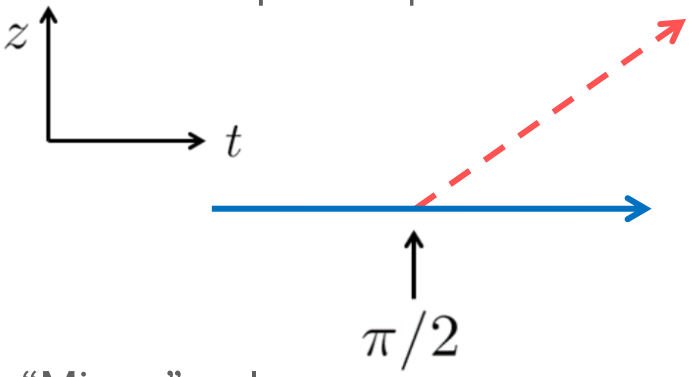
Photon Absorption:

Stimulated Emission:

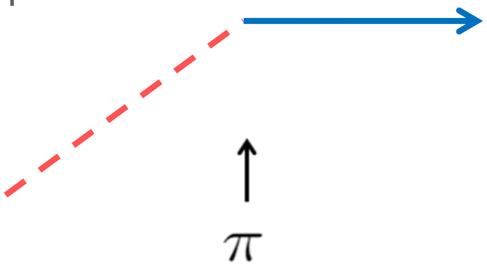


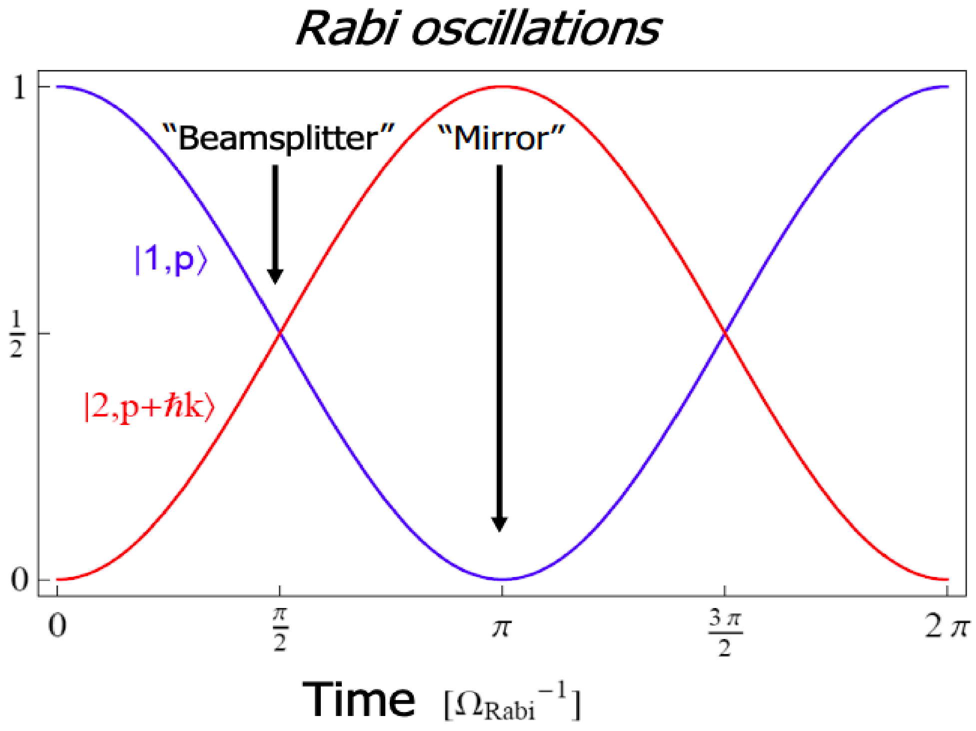
Rabi oscillations

"Beam-splitter" pulse:

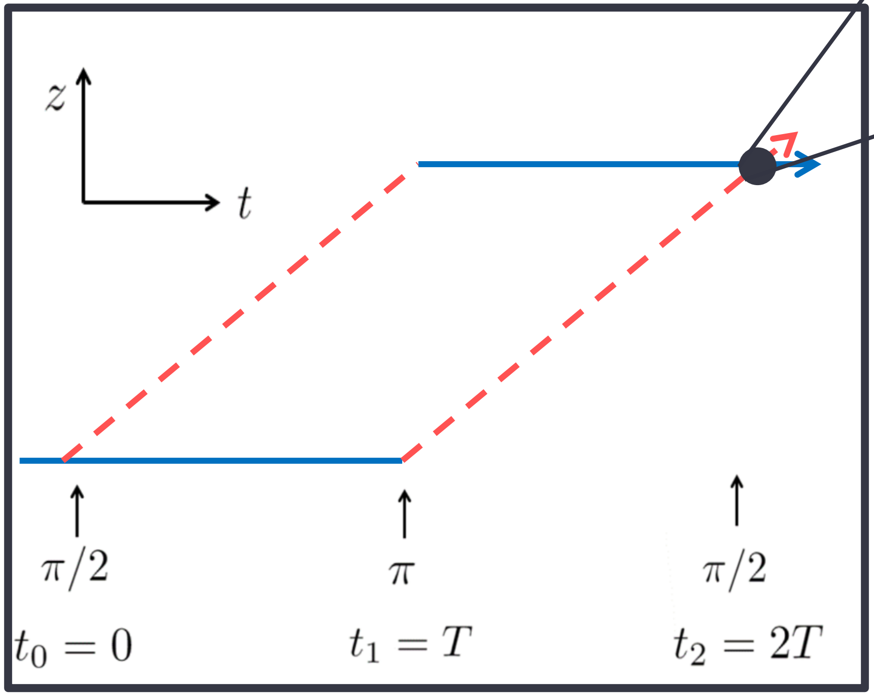


"Mirror" pulse:





AI sequence



Mach-Zehnder interferometer

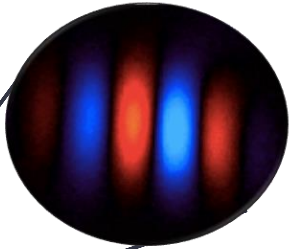


Image atom fringes and measure phase

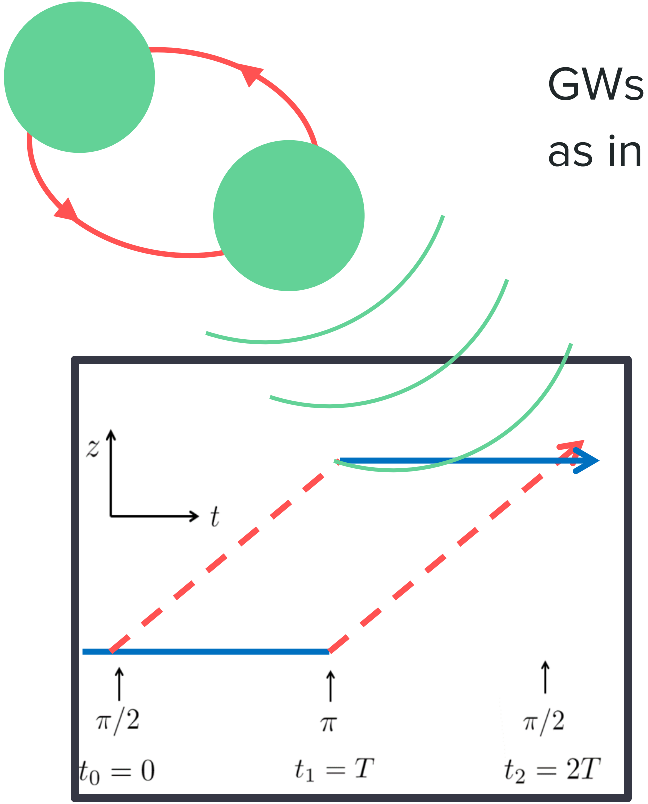
$$\Delta\phi_{MZ} = kgT^2$$

Leading order phase depends on gravitational acceleration

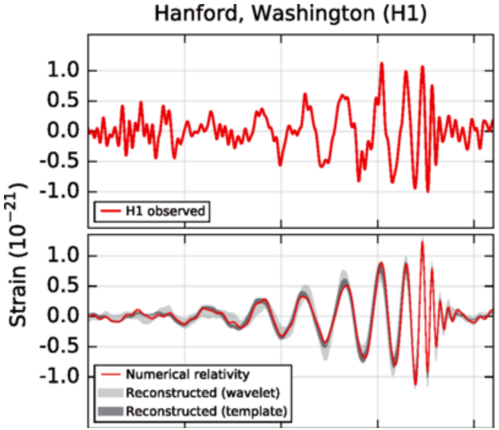
Atom interferometry for fundamental physics

John Carlton
PhD Candidate
King's College London

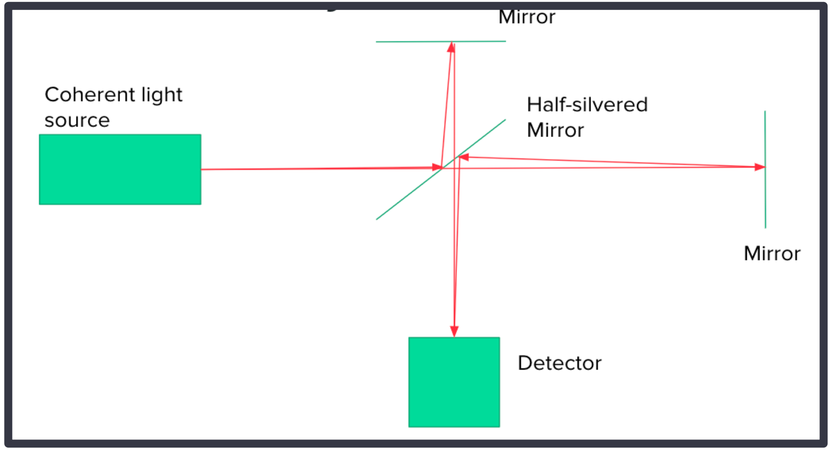
Gravity just like LIGO



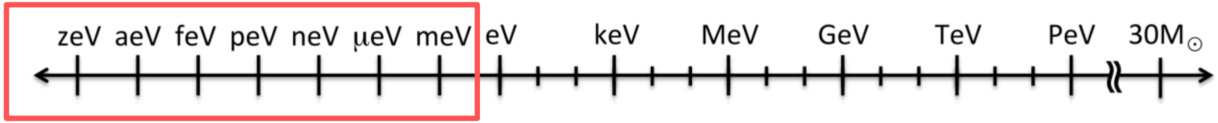
GWs change path length just as in laser interferometers!



$$h = \frac{\delta L}{L}$$



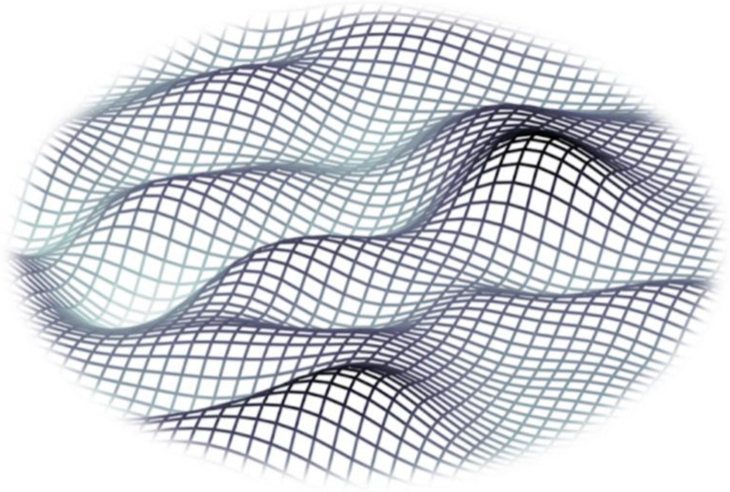
A new way to detect ultra-light dark matter



Scalar example:

With high enough occupation number, model scalar ULDM as an oscillating classical field

$$\phi(t, \mathbf{x}) \simeq \frac{\sqrt{2\rho_{\mathrm{DM}}}}{m_\phi} \cos\left(\omega_\phi t - \mathbf{k}_\phi \cdot \mathbf{x} + \theta\right)$$



Badurina et al. arxiv: 2109.10965

A new way to detect ultra-light dark matter

$$\mathcal{L} \supset \mathcal{L}_{\mathrm{SM}} + \mathcal{L}_\phi$$

$$\mathcal{L}_\phi \supset \phi(t, \mathbf{x})\sqrt{4\pi G_N}\left[\frac{d_e}{4e^2}F_{\mu\nu}F^{\mu\nu} - d_{m_e} m_e \overline{\psi}_e \psi_e\right]$$

photon coupling

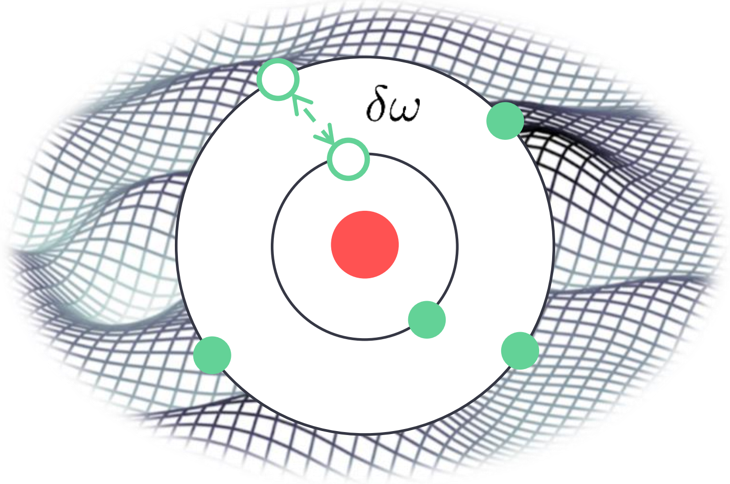
electron coupling

ULDM field causes small oscillations in electron mass and fine-structure constant

$$m_e(t, \mathbf{x}) = m_e\left[1 + d_{m_e}\sqrt{4\pi G_N}\phi(t, \mathbf{x})\right]$$

$$\alpha(t, \mathbf{x}) \approx \alpha\left[1 + d_e\sqrt{4\pi G_N}\phi(t, \mathbf{x})\right]$$

Changes atomic transition energy and can be seen in phase measurements!



Badurina et al. arxiv: 2109.10965

The AION-10 Experiment

University of Oxford, Beecroft Building

ULDM signals in a busy environment

Mask signals from moving objects near the detector to recover a ULDM spike!