Adiabatic processes
CM meets AMO

CONDENSED MATTER SEMINAR:
"OHM’S LAW AND BEYOND FOR ATOM CIRCUITS"

Chris Lobb, Maryland
1 pm Friday

Campbell group, NIST/Maryland

Esslinger group, ETH Zurich

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Neely group, Univ. of Queensland
~arbitrary structures possible
the cesium fountain clock

$\Delta E$ determines the SI second (and meter)
$\Delta E \propto 1/\Delta t$

For many experiments,
long interaction time = large region of space

Hard to keep microwaves/laser ($\Omega$) and external fields constant over large region of space
From last time...

**Ramsey signal**

\[
T = 10 \\
\Omega = 1
\]

approx/idealized form

![Graph of Ramsey signal with population on the y-axis and \(\delta\) on the x-axis. The graph shows a peak at \(\delta = 0\) with oscillations around it.](image1)

![Graph showing the probability of transition as a function of frequency (Hz). The graph is an amplitude spectrum with a central peak.](image2)
Phase accumulation in Ramsey interferometry

Entanglement-Based dc Magnetometry with Separated Ions

T. Ruster, H. Kaufmann, M. A. Luda, V. Kaushal, C. T. Schmiegelow, F. Schmidt-Kaler, and U. G. Poschinger

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FIG. 2. Incremental measurement of the phase accumulation rate $\Delta \omega$ at an ion distance of $d = 6.2$ mm. A linear fit to measurements of the accumulated phase $\varphi$ at predefined interrogation times (top part), and the fit residuals $\delta \varphi$ for each phase measurement are shown (bottom part). For each point, measurements of both operators have been repeated 50 times.
More complex pulse sequences

Spin-echo (refocusing pulses)
From last time...

More complex pulse sequences
From last time...

More complex procedures

WAHUHA
Adiabatic processes
Adiabatic rapid passage (ARP)

\[ H = \delta(t)\hat{\sigma}_z + \Omega(t)\hat{\sigma}_x \]
Adiabatic rapid passage (ARP)

\[ H = \delta(t)\hat{\sigma}_z + \Omega(t)\hat{\sigma}_x \]

faster by factor of 4
Adiabatic rapid passage (ARP)

\[ H = \delta(t) \hat{\sigma}_z + \Omega(t) \hat{\sigma}_x \]

slightly rotated initial state
Superadiabatic (counterdiabatic) protocols

High-fidelity quantum driving

Mark G. Bason¹, Matthieu Viteau¹, Nicola Malossi², Paul Huillery¹,³, Ennio Arimondo¹,²,⁴, Donatella Ciampini¹,²,⁴, Rosario Fazio⁵, Vittorio Giovannetti⁵, Riccardo Mannella⁴ and Oliver Morsch¹,*
Superadiabatic (counterdiabatic) protocols

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Non-adiabatic response

**Observation of topological transitions in interacting quantum circuits**

P. Roushan\(^1\)^*, C. Neill\(^1\)^*, Yu Chen\(^1\)^†, M. Kolodrubetz\(^2\), C. Quintana\(^1\), N. Leung\(^1\), M. Fang\(^1\), R. Barends\(^1\)^†, B. Campbell\(^1\), Z. Chen\(^1\), B. Chiaro\(^1\), A. Dunsworth\(^1\), E. Jeffrey\(^1\)^†, J. Kelly\(^1\), A. Megrant\(^1\), J. Mutus\(^1\)^†, P. J. J. O’Malley\(^1\), D. Sank\(^1\)^†, A. Vainsencher\(^1\), J. Wenner\(^1\), T. White\(^1\), A. Polkovnikov\(^2\), A. N. Cleland\(^1\) & J. M. Martinis\(^1,3\)
Non-adiabatic response – berry curvature

boron-nitride lattice
Break inversion sym.
Open Dirac points

- State tomography from quench dynamics
  amplitude $\sin \theta$  phase $\phi$  Berry curvature

- Quantization of the Chern number:
  $C=0.005(6)$  $C=-0.016(8)$

Weitenberg/Sengstock group, Hamburg
Three-level systems
STImulated Raman Adiabatic Passage

Populations

Time [arb.]

\( \Omega_{1,2} \)