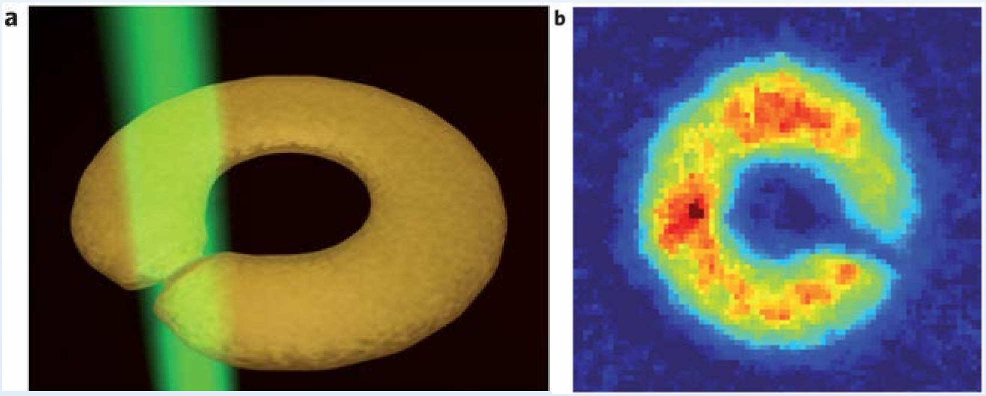
Advertisements

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

Chris Lobb, Maryland
1 pm Friday



Campbell group
NIST/Maryland

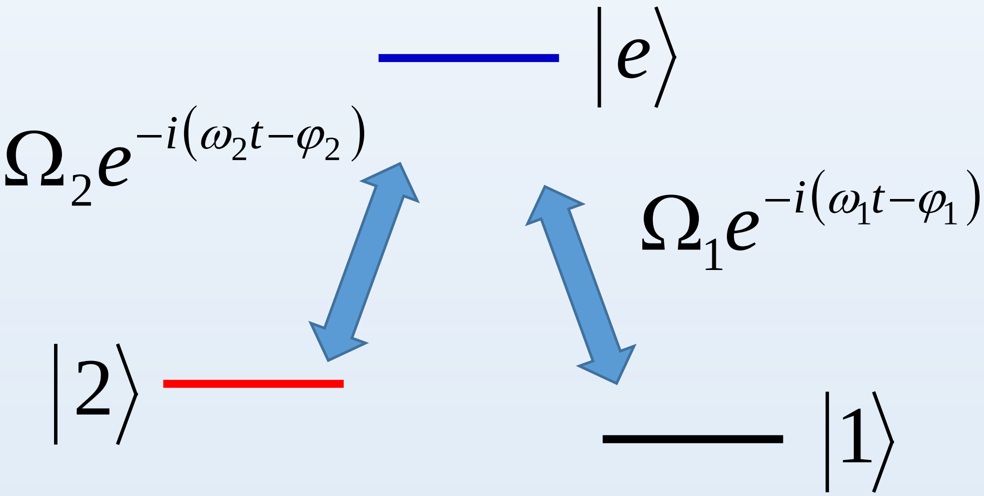
Condensed Matter/AMO Journal Club

"Experimental Challenges to Inducing Superconductivity in Quantum Hall Edge States"
Today – 4 pm, 464 Loomis
Speaker: Erik Huemiller

(1) G.-H. Lee, K.-F. Huang, D. K. Efetov, D. S. Wei, S. Hart, T. Taniguchi, K. Watanabe, A. Yacoby, and P. Kim. "Inducing Superconducting Correlation in Quantum Hall Edge States." Nature Physics (April 2017).

Finishing up from last time…

Three-level systems – “Lambda” system



Finishing up from last time…

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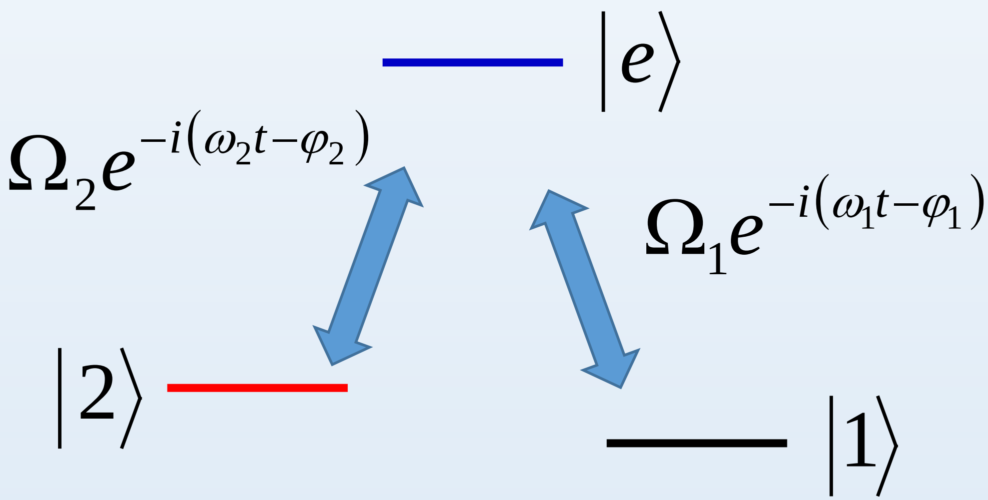
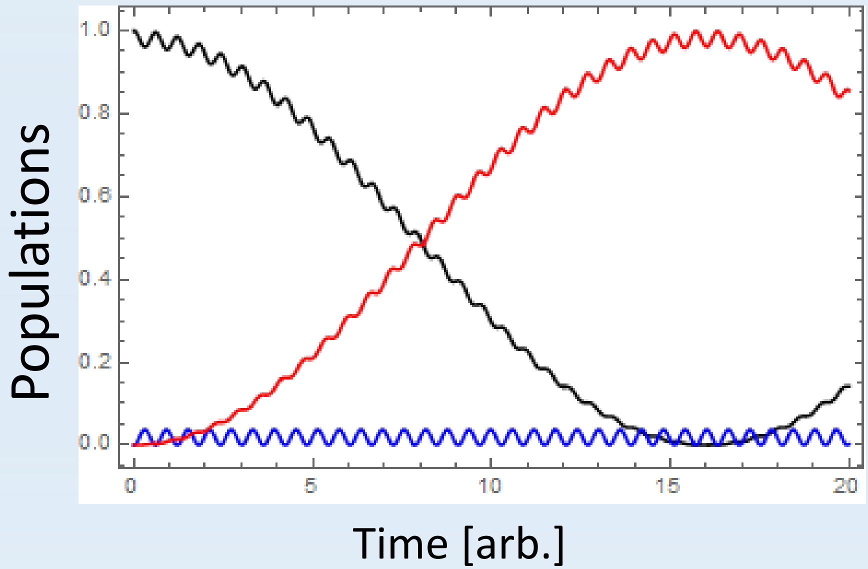
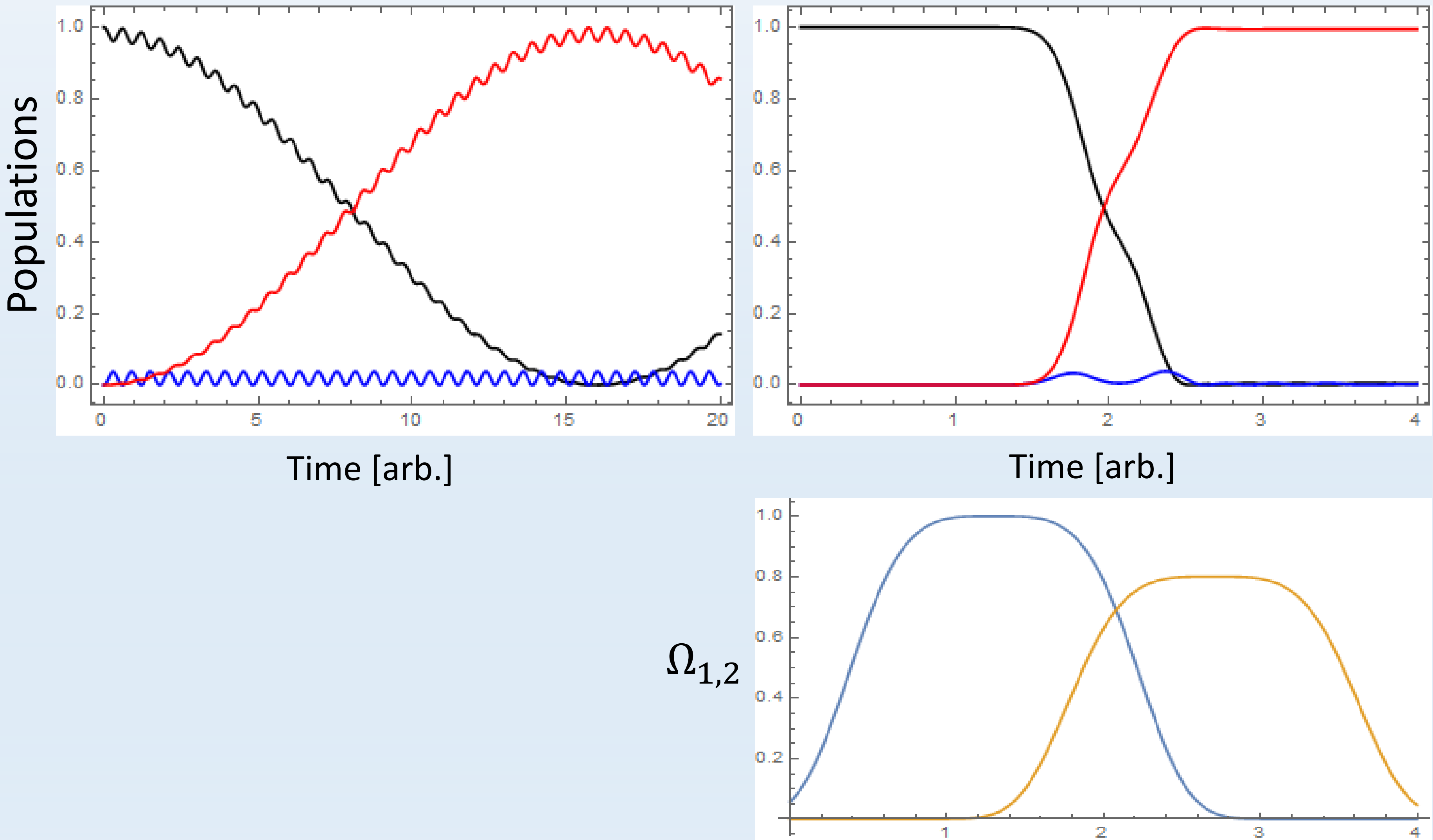


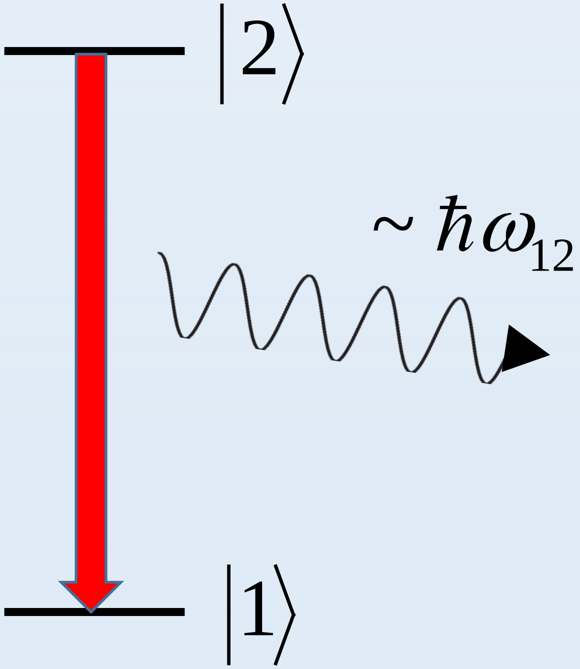


Finishing up from last time…

STImulated Raman Adiabatic Passage

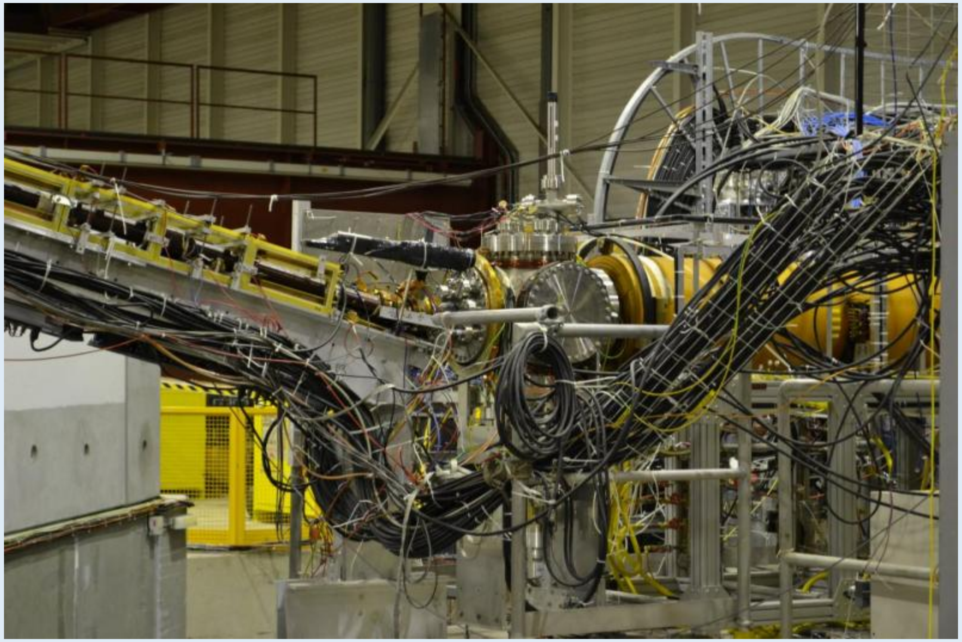


Open quantum systems:
Dissipation in atomic physics / ultracold atoms



Open quantum systems:
Dissipation in atomic physics / ultracold atoms

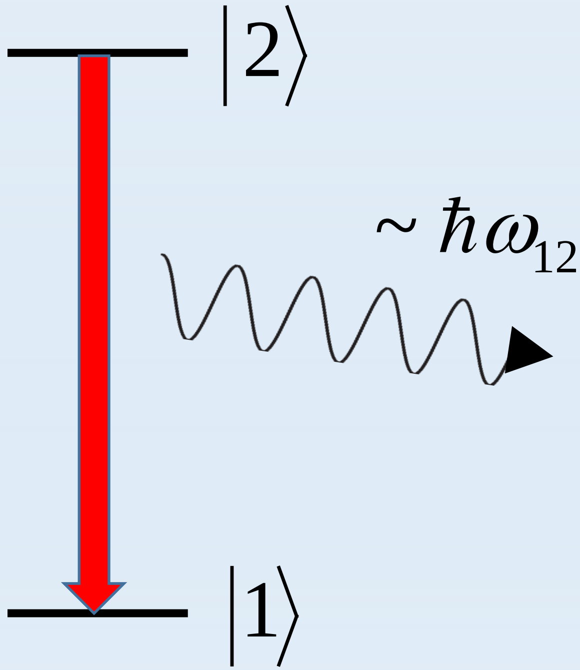
We work with fairly well-isolated systems, held in ultrahigh vacuum, but on some timescale it's going to interact with the "environment." If we're not monitoring the environment [hard to do], then we'll lose information about our system.



ATRAP experiment

How do we treat this? What role does dissipation play in AMO systems?

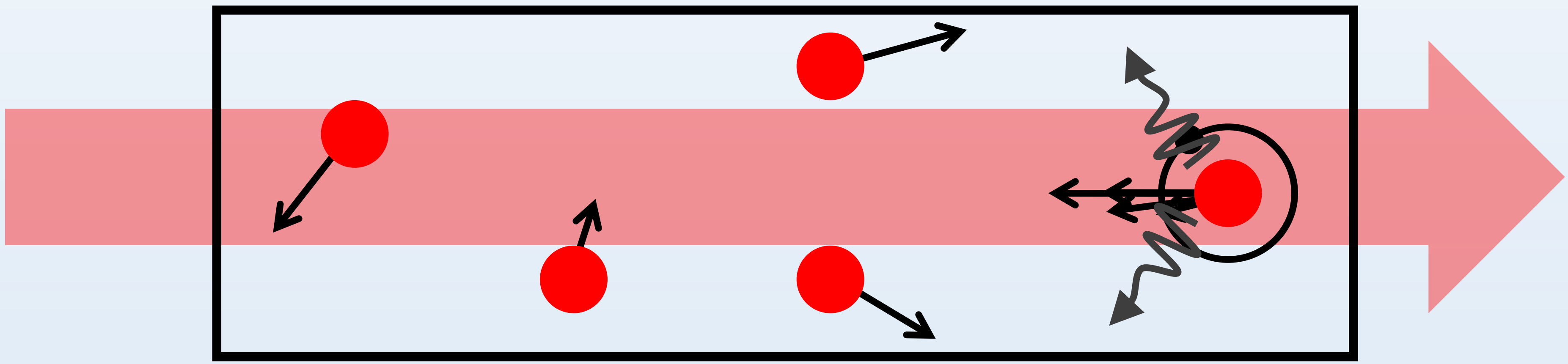
Laser-cooling of atoms

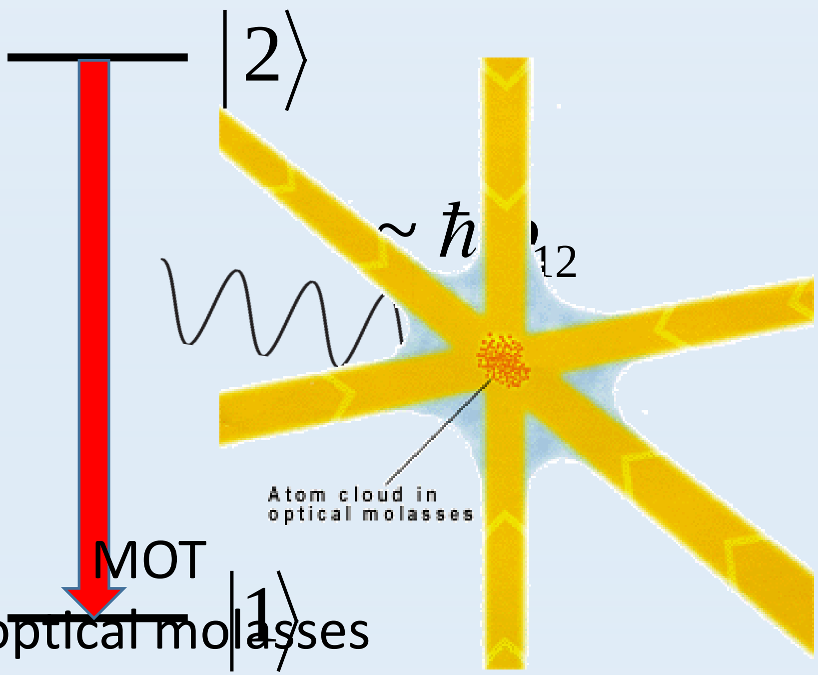


Photon momentum imparted when
the atom is first excited. The decay
let's us "cycle" this process over and over

ALSO – we start with high-entropy ensemble,
the degrees of freedom of the light field help
accommodate the removal of entropy

Laser-cooling of atoms





MOT
& optical molasses

T ~ 300-400 K

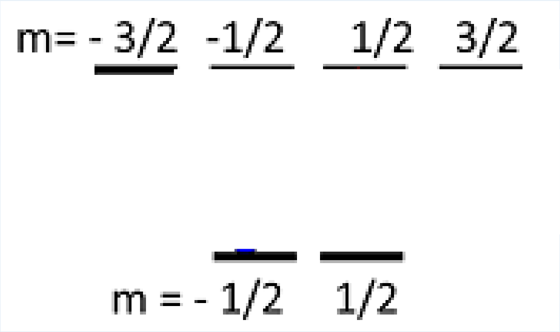
many cycles

T ~ few millionths of 1 K

1997 Nobel Prize in Physics
Chu, Phillips, Cohen-Tannoudji

Optical pumping

e.g., take a thermal ensemble and prepare a spin-polarized sample

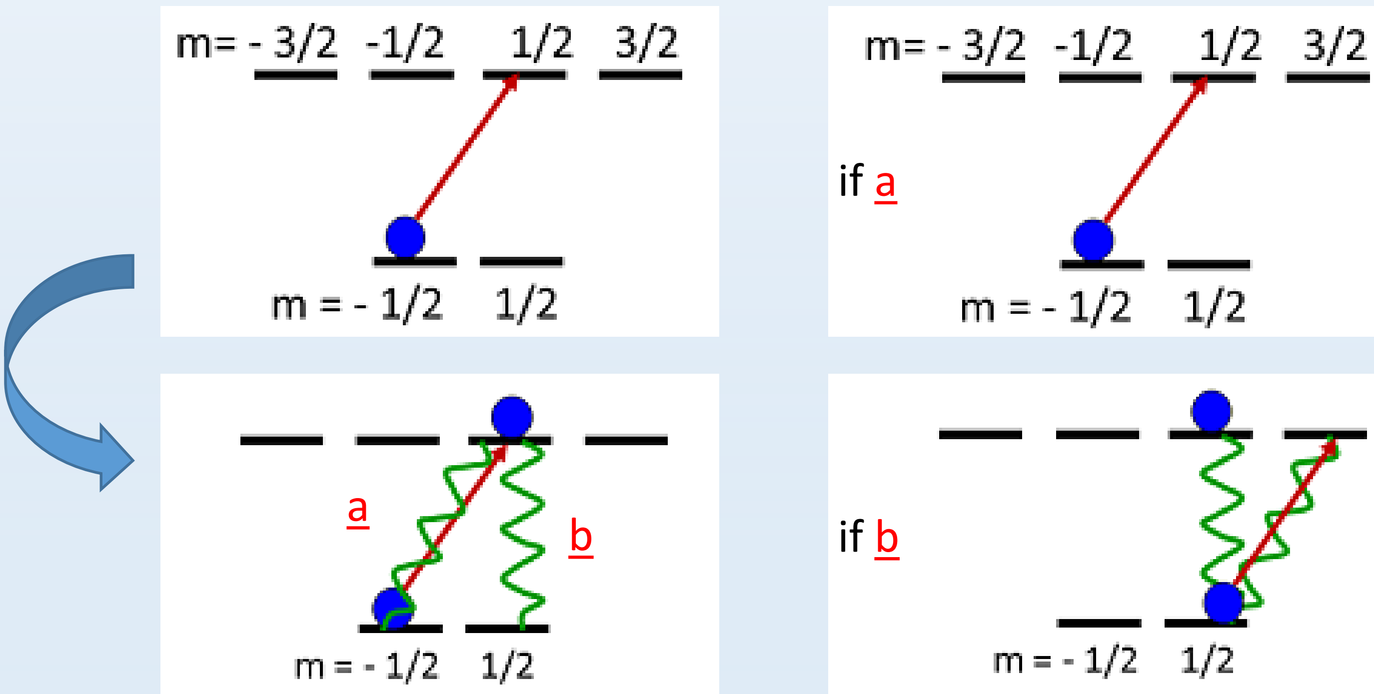


Let's say we want to prepare in the state |1/2 , 1/2>

→ Polarized light + sponteneous decay

Optical pumping

e.g., take a thermal ensemble and prepare a spin-polarized sample



1966 Nobel Prize in Physics

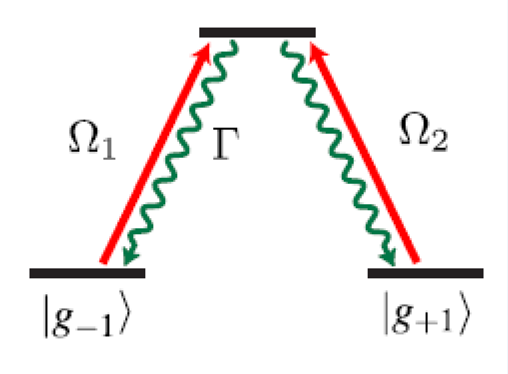
Alfred Kastler

“Optical Methods for Studying Hertzian Resonances”

Dark states

States decoupled from rest of dynamics – no excited state component

Our 3-level system, with loss



population gets "trapped" in dark state at long times

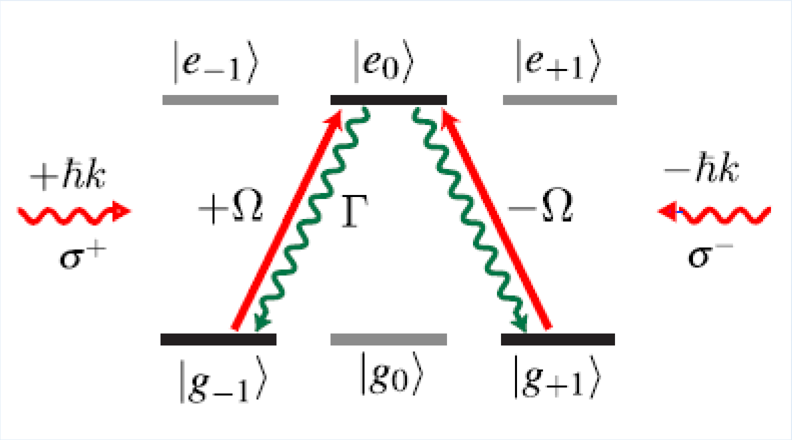
$$|D\rangle \sim \Omega_2 |g_{-1}\rangle - \Omega_1 |g_{+1}\rangle$$ Dark state

$$|B\rangle \sim \Omega_1 |g_{-1}\rangle + \Omega_2 |g_{+1}\rangle$$ Bright state

from Zoller…

Velocity-selective coherent population trapping

sub-recoil cooling!!!



$$|D,p\rangle \sim |g_{-1}, p-\hbar k\rangle + |g_{+1}, p+\hbar k\rangle$$
$$|B,p\rangle \sim |g_{-1}, p-\hbar k\rangle - |g_{+1}, p+\hbar k\rangle$$

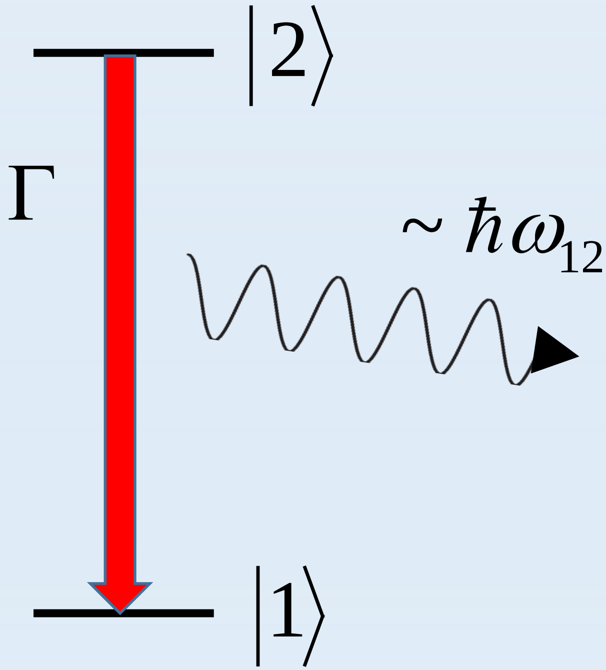
also…
gray molasses,
related techniques…

from Zoller…

developed by Cohen-Tannoudji/Chu/etc.

OK, important to laser-cooling. What else?

Can we modify how our system interacts with the environment to influence processes like spontaneous emission?



Purcell enhancement (1940 ; 1952 Nobel)

Enhance Γ: bring some "emitter" near a structure / waveguide matching its frequency

Effectively suppress Γ: put the emitter into a "cavity" with frequency matched to resonance. If photon lifetime in cavity is long enough, reabsorption more likely than loss

OK, important to laser-cooling. What else?

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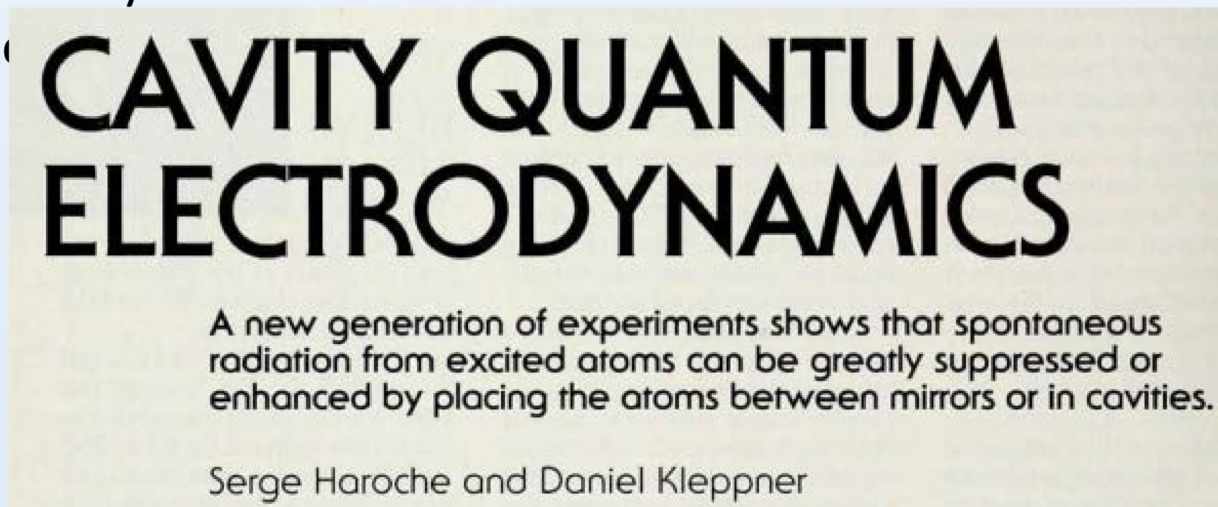
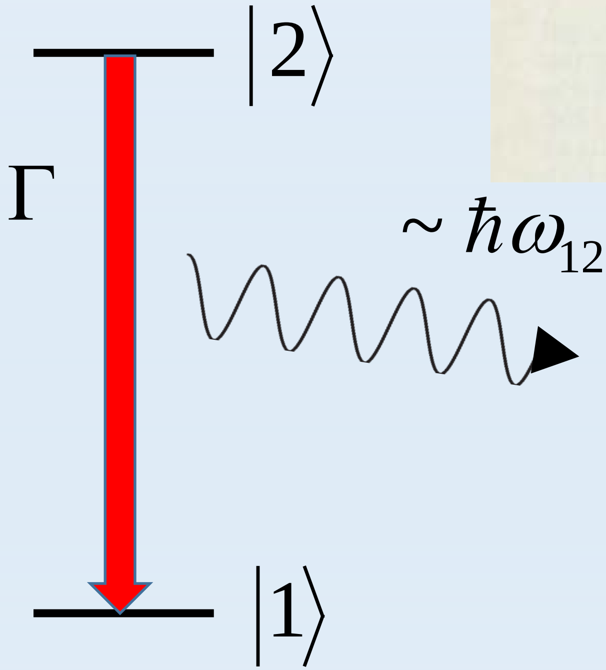

CAVITY QUANTUM ELECTRODYNAMICS

A new generation of experiments shows that spontaneous radiation from excited atoms can be greatly suppressed or enhanced by placing the atoms between mirrors or in cavities.

Serge Haroche and Daniel Kleppner

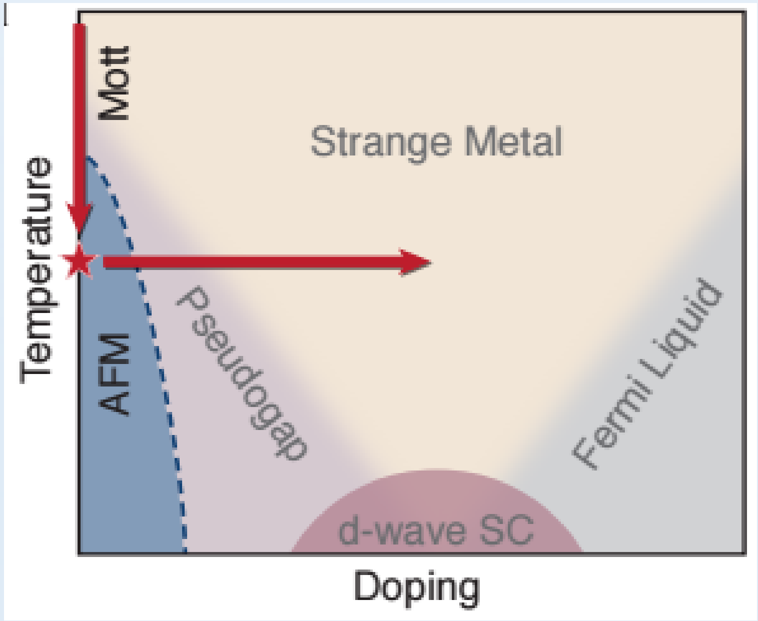


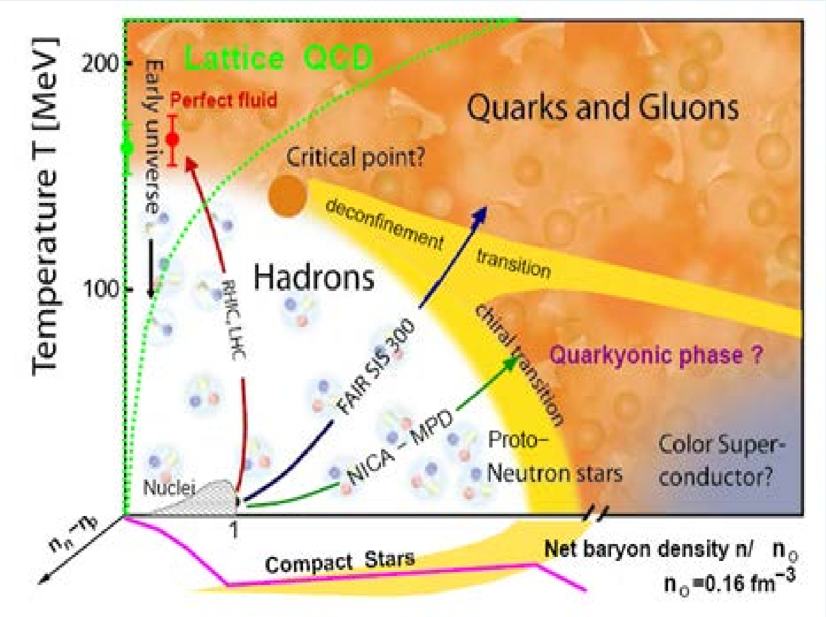
Effectively suppress Γ: put the emitter into a "cavity" with frequency matched to resonance. If photon lifetime in cavity is long enough, reabsorption more likely than loss

Dissipation as a resource for many-body physics

General theme in many-body physics – going to low energies leads to emergent behavior

i.e., due to energetic restriction of accessible Hilbert space





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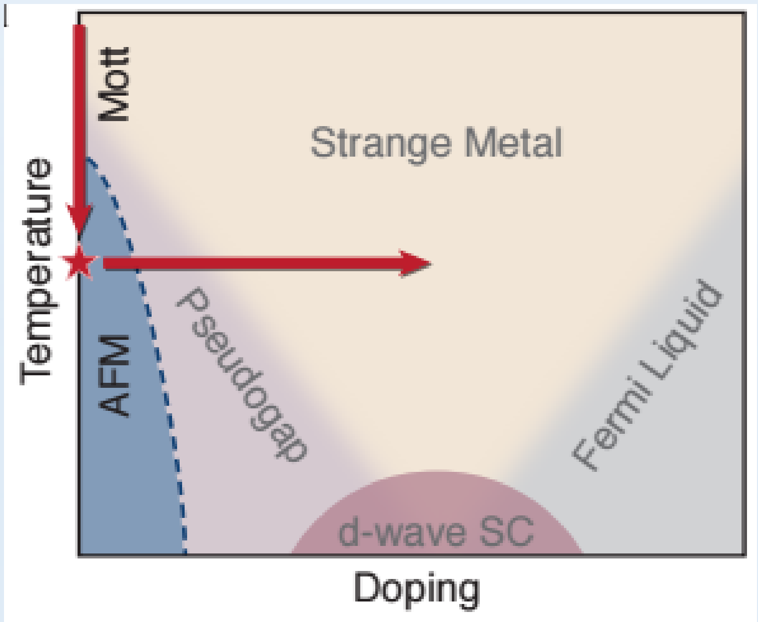
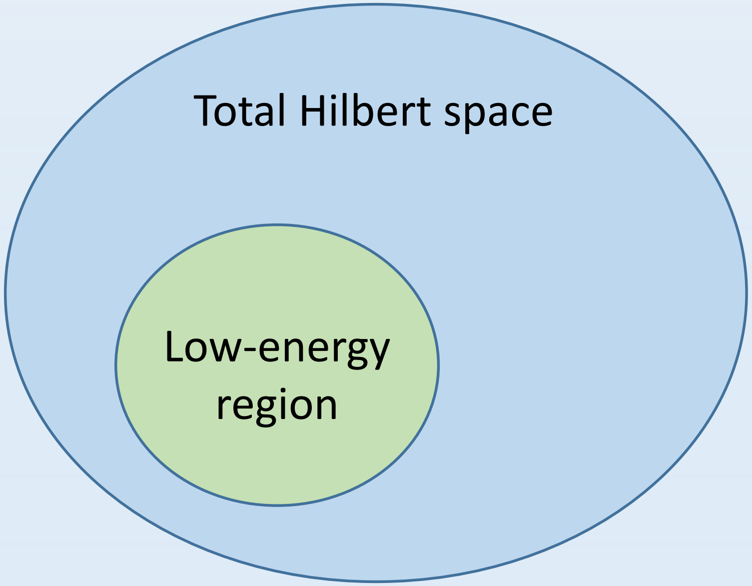


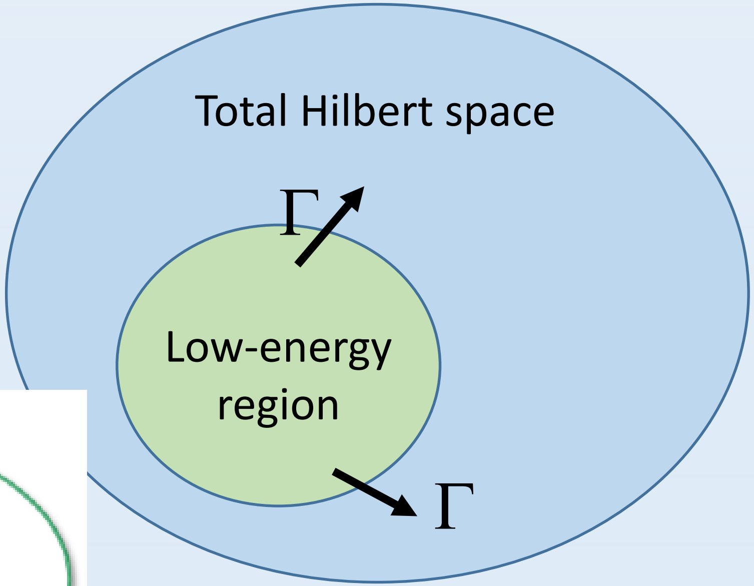


Dissipation as a resource for many-body physics

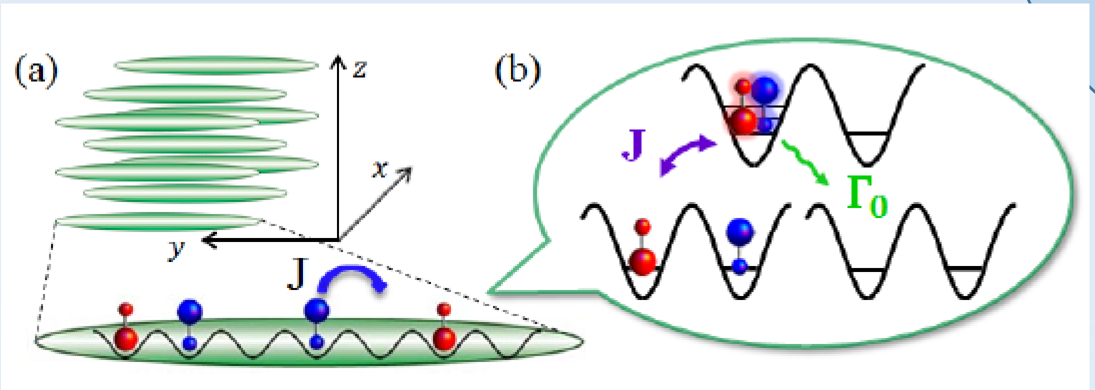
If we start in some part of Hilbert space, can we restrict ourselves to this region using dissipation?

→ answer, of course

Basically, just the quantum Zeno effect

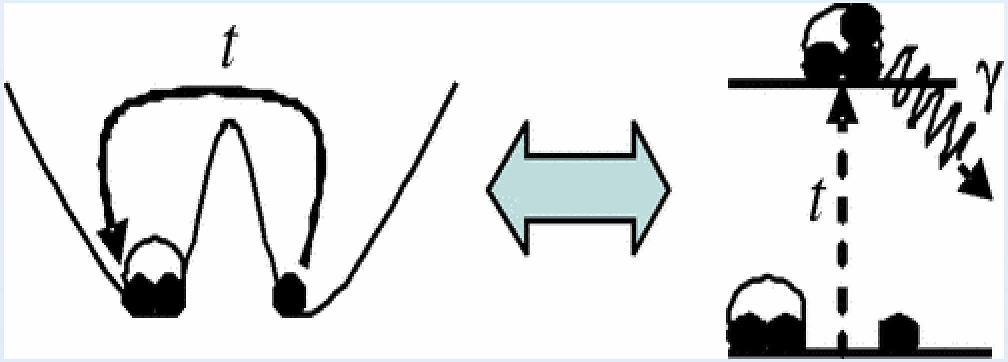


ex: stabilization of ultracold molecules against exothermic chemical reactions



Dissipation-constrained dynamics

How about for cold atoms? Loss due to 3-body molecular recombination



Stabilization of the p-Wave Superfluid State in an Optical Lattice
Y.-J. Han, Y.-H. Chan, W. Yi, A. J. Daley, S. Diehl, P. Zoller, and L.-M. Duan
Phys. Rev. Lett. 103, 070404 – Published 14 August 2009

Dissipation-constrained dynamics

PRL 112, 120406 (2014) PHYSICAL REVIEW LETTERS week ending 28 MARCH 2014

Constrained Dynamics via the Zeno Effect in Quantum Simulation: Implementing Non-Abelian Lattice Gauge Theories with Cold Atoms

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[3]Institute for Theoretical Physics, University of Innsbruck, 6020 Innsbruck, Austria
(Received 2 August 2013; published 26 March 2014)

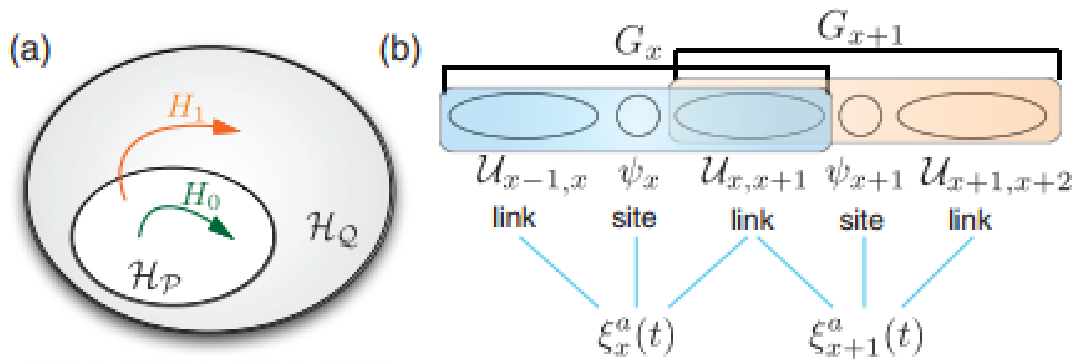
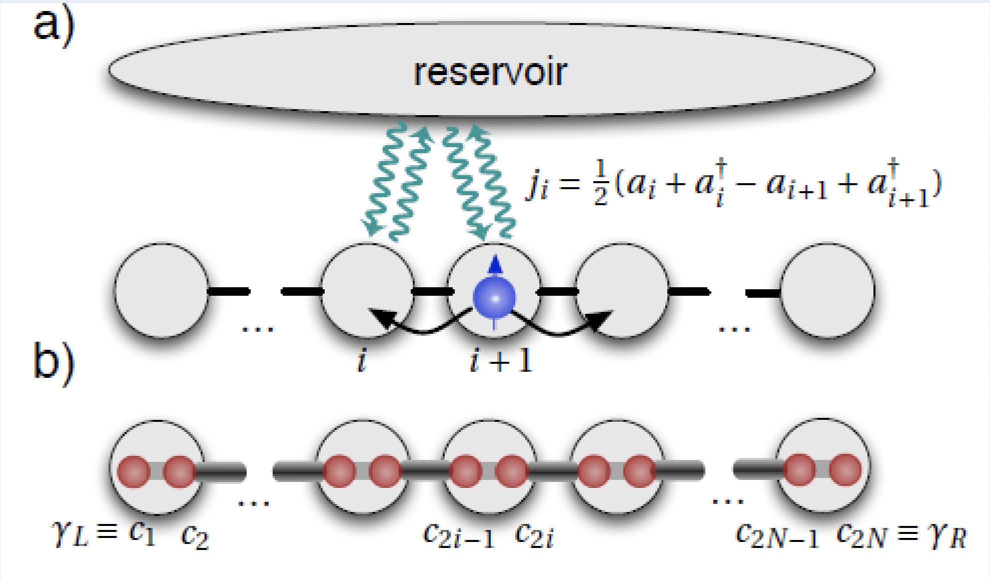


FIG. 1 (color online). Dissipative protection of gauge invariance in implementations of a lattice gauge theory (LGT). (a) The

“Dark states” in many-body systems

Making stable Majoranas through “dark state” engineering



many, many more examples…

analogs of QED

new cooling techniques

etc.

Topology by dissipation in atomic quantum wires
Sebastian Diehl, Enrique Rico, Mikhail A. Baranov, & Peter Zoller
Nature Physics 2011