Quantum dynamics of a driven three-level Josephson-atom maser

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With: Nicolas Didier, Frank Hekking

Phys. Rev. B **82**, 214507 (2010)

TU Delft
Technische Universiteit Delft

Completed work

1. *Interaction Constants and Dynamic Conductance of a Gated Wire*
   Ya. M. Blanter, F. W. J. Hekking, and M. Büttiker,
   Phys. Rev. Lett. **81**, 1925 (1998)

2. *Supercurrent in long SFFS junctions with antiparallel domain configuration*
   Ya. M. Blanter and F. W. J. Hekking
   Phys. Rev. B **69**, 024525 (2004)

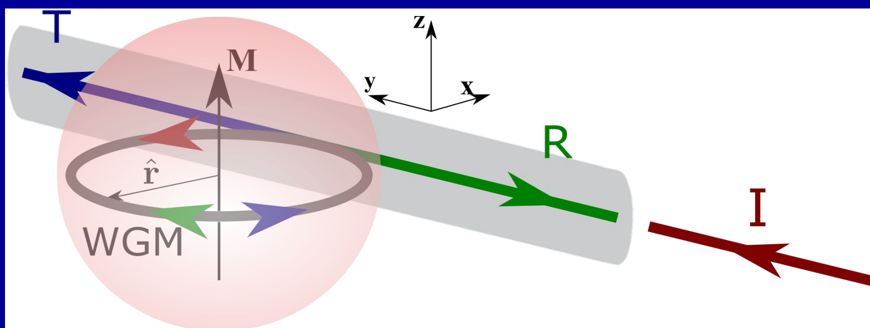
3. *Quantum dynamics of a driven three-level Josephson-atom laser*
   N. Didier, Ya. M. Blanter, and F. W. J. Hekking
   Phys. Rev. B **82**, 214507 (2010)

Not completed work

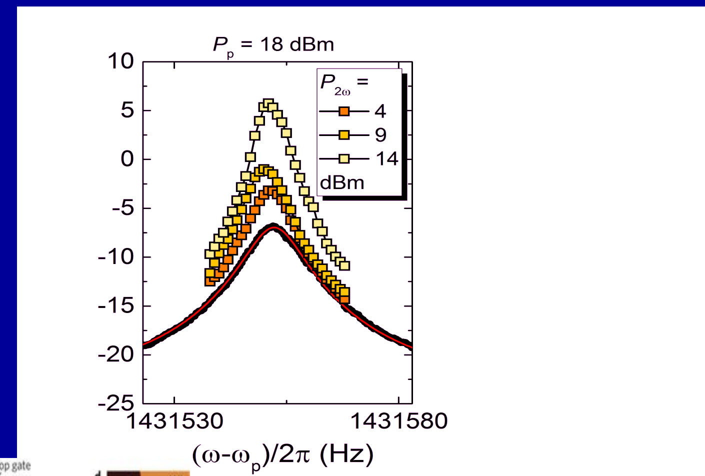
- Extension of Blanter – Hekking – Büttiker to the wire with a barrier
- Self-consistent theory of radiation of a Josephson junction
- Nanomechanical cooling using superconductors
- ...

My recent work

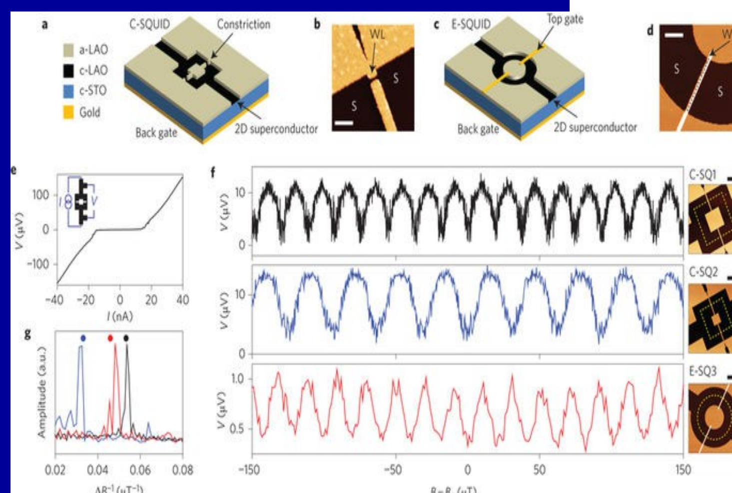
- Optomagnonics and magnon manipulation by light
- Non-linear nano- and optomechanics
- Nanostructures with complex oxides



Sanchar Sharma, Gerrit Bauer



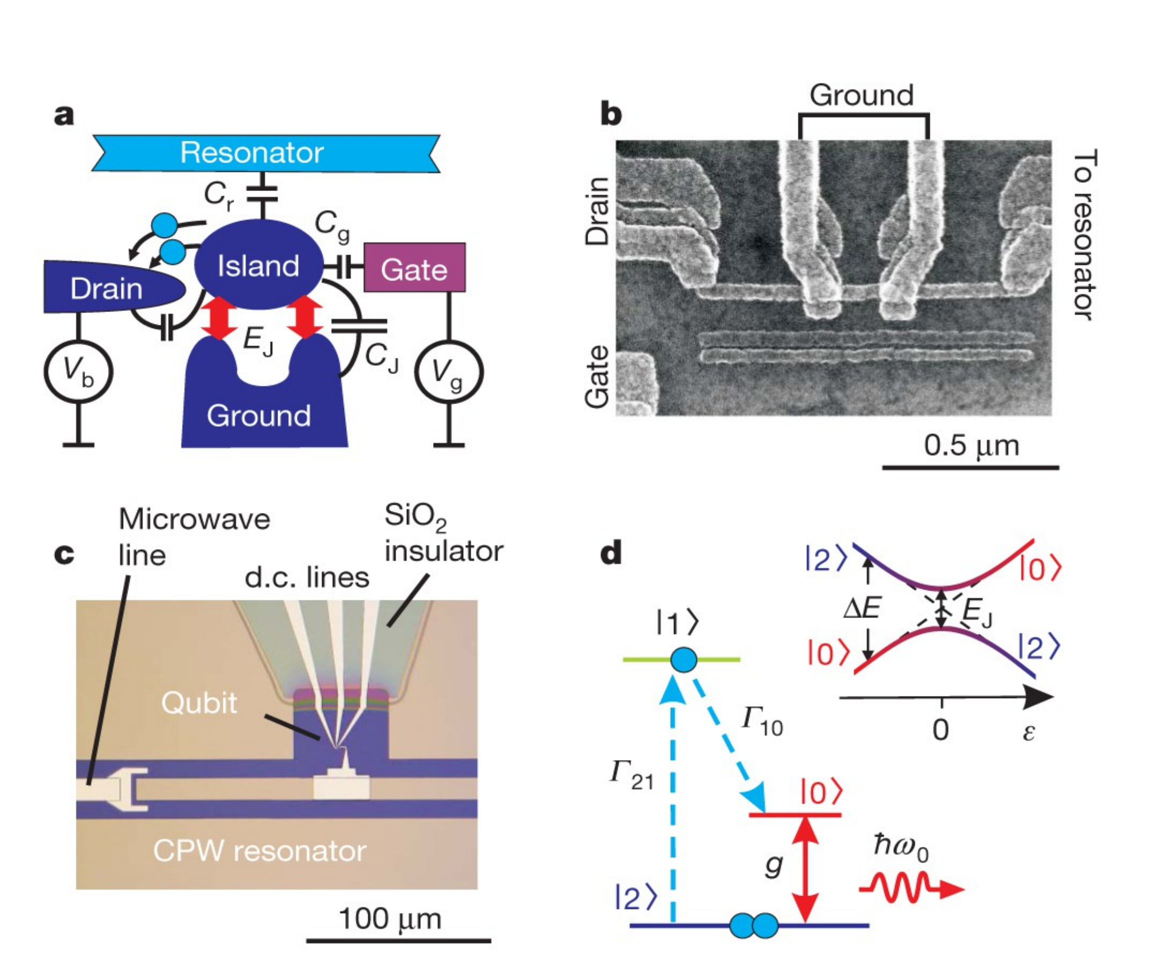
Gary Steele Lab



Andrea Caviglia Lab

Single artificial-atom lasing

O. Astafiev, K. Inomata, A. O. Niskanen, T. Yamamoto, Yu. A. Pashkin, Y. Nakamura, and J. S. Tsai
Nature **449**, 588 (2007)



Cooper pair box coupled to a microwave resonator

Single artificial-atom lasing

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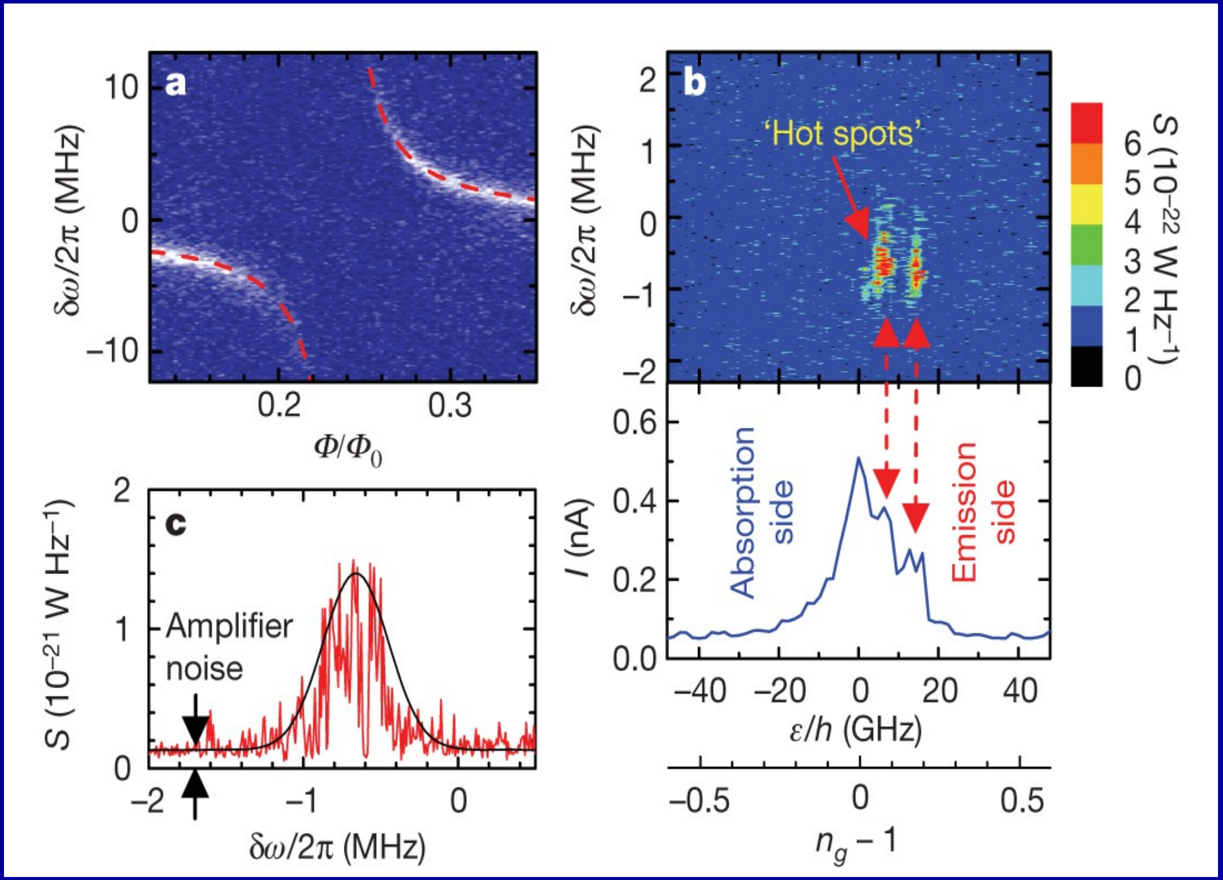

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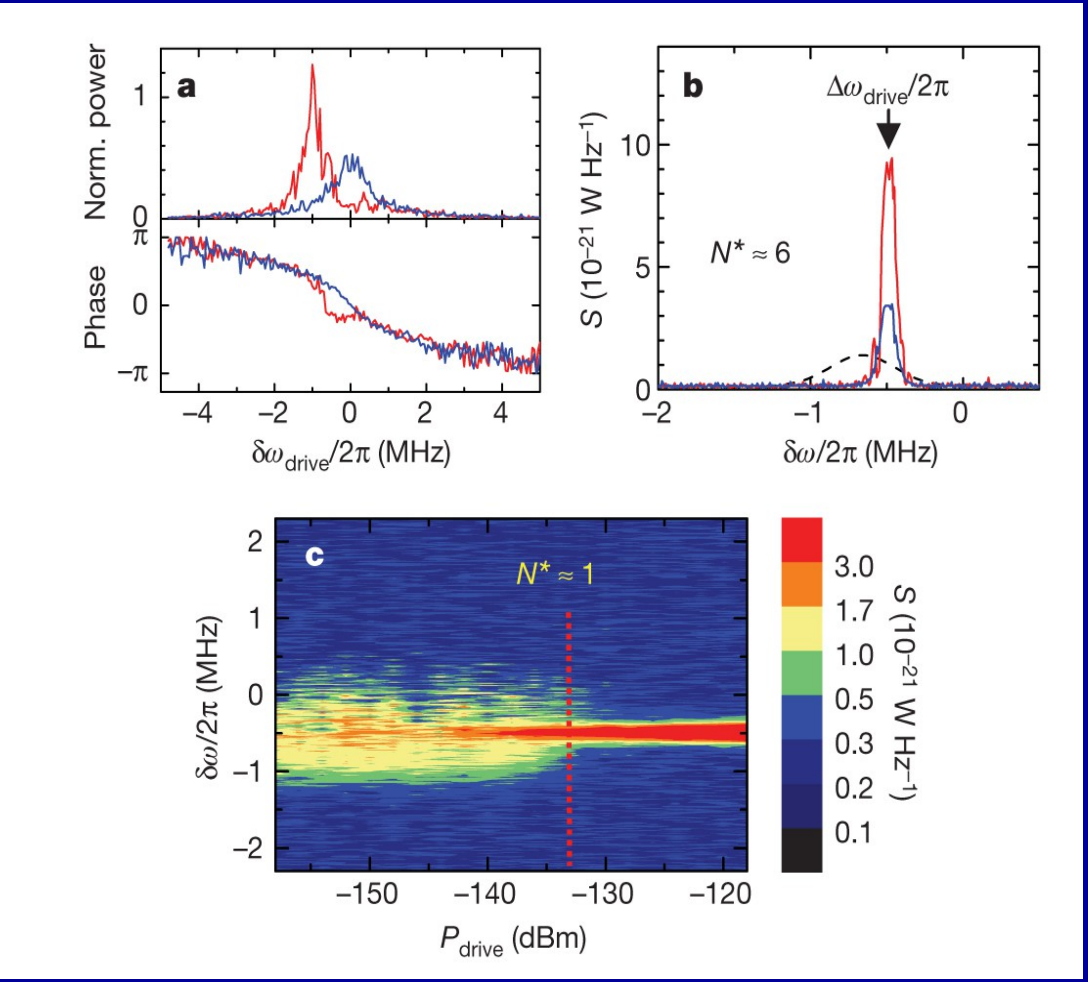


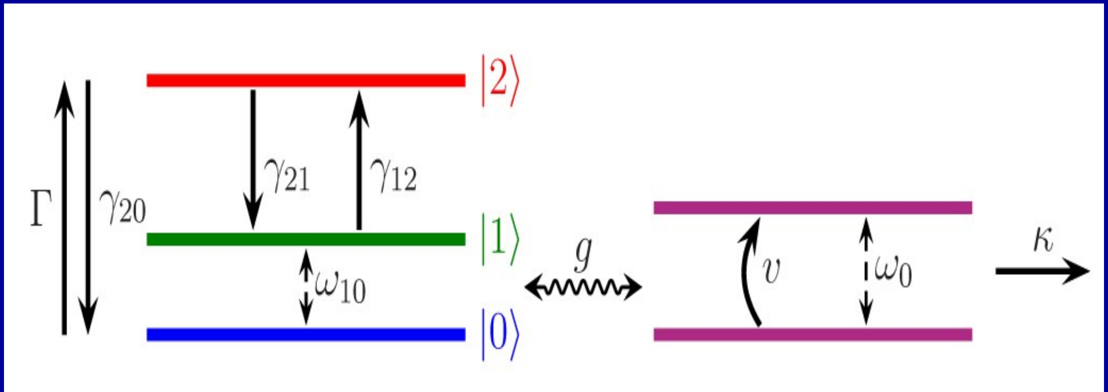
Single artificial-atom lasing

Theory:

S. André, V. Brosco, A. Shnirman, and G. Schön
Phys. Rev. A 7**9**, 053848 (2009)

S. André, V. Brosco, M. Marthaler, A. Shnirman, and G. Schön
Phys. Scr. T 7**9**, 014016 (2009)

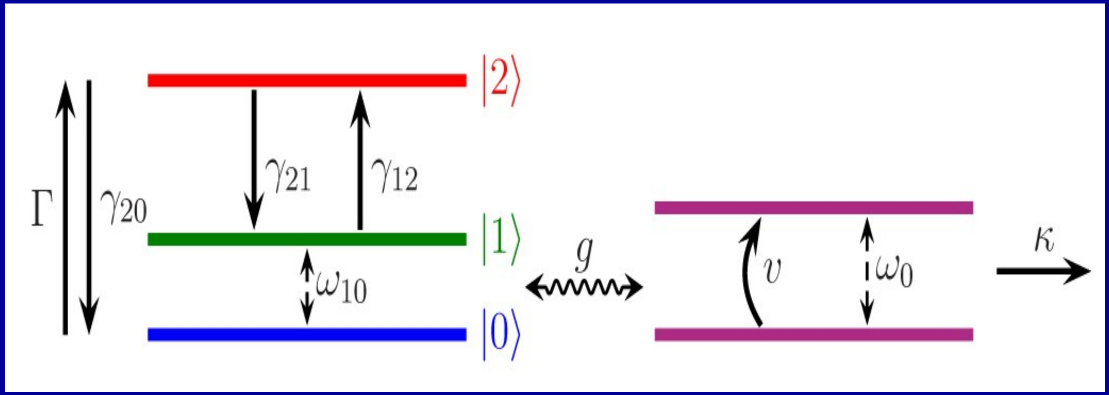
Hamiltonian



Jaynes-Cummings Hamiltonian:

$$H = \frac{1}{2}\hbar\omega_{10}\sigma_z + \hbar\omega_0 \hat{a}^\dagger \hat{a} + i\hbar g\left(\sigma_{01}\hat{a}^\dagger - \sigma_{10}\hat{a}\right)$$

Lindblad equation



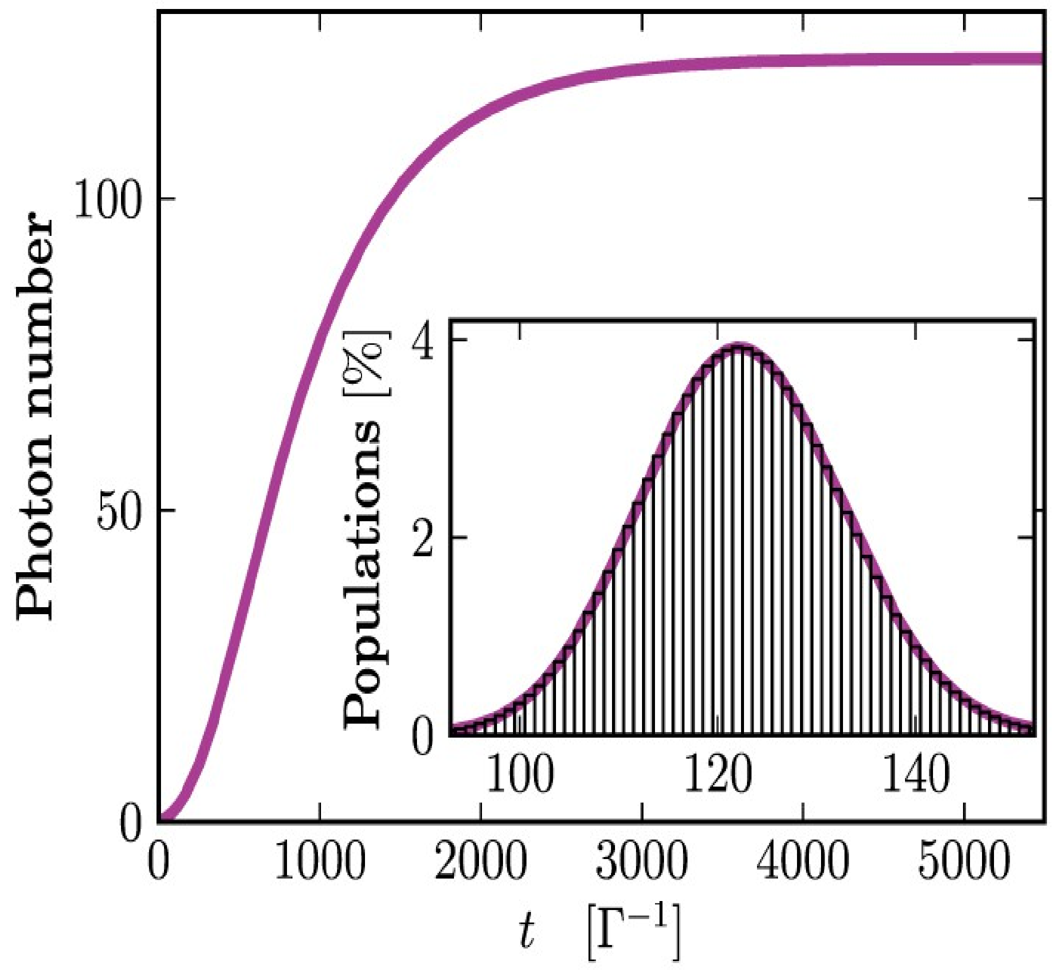
$$\dot{\rho} = \frac{1}{i\hbar}\left[\hat{H}, \rho\right] + \hat{L}\rho$$

$$\hat{L} = \hat{L}_{\Gamma} + \hat{L}_{\gamma_{21}} + \hat{L}_{\gamma_{20}} + \hat{L}_{\gamma_{12}} + \hat{L}_{\kappa}$$

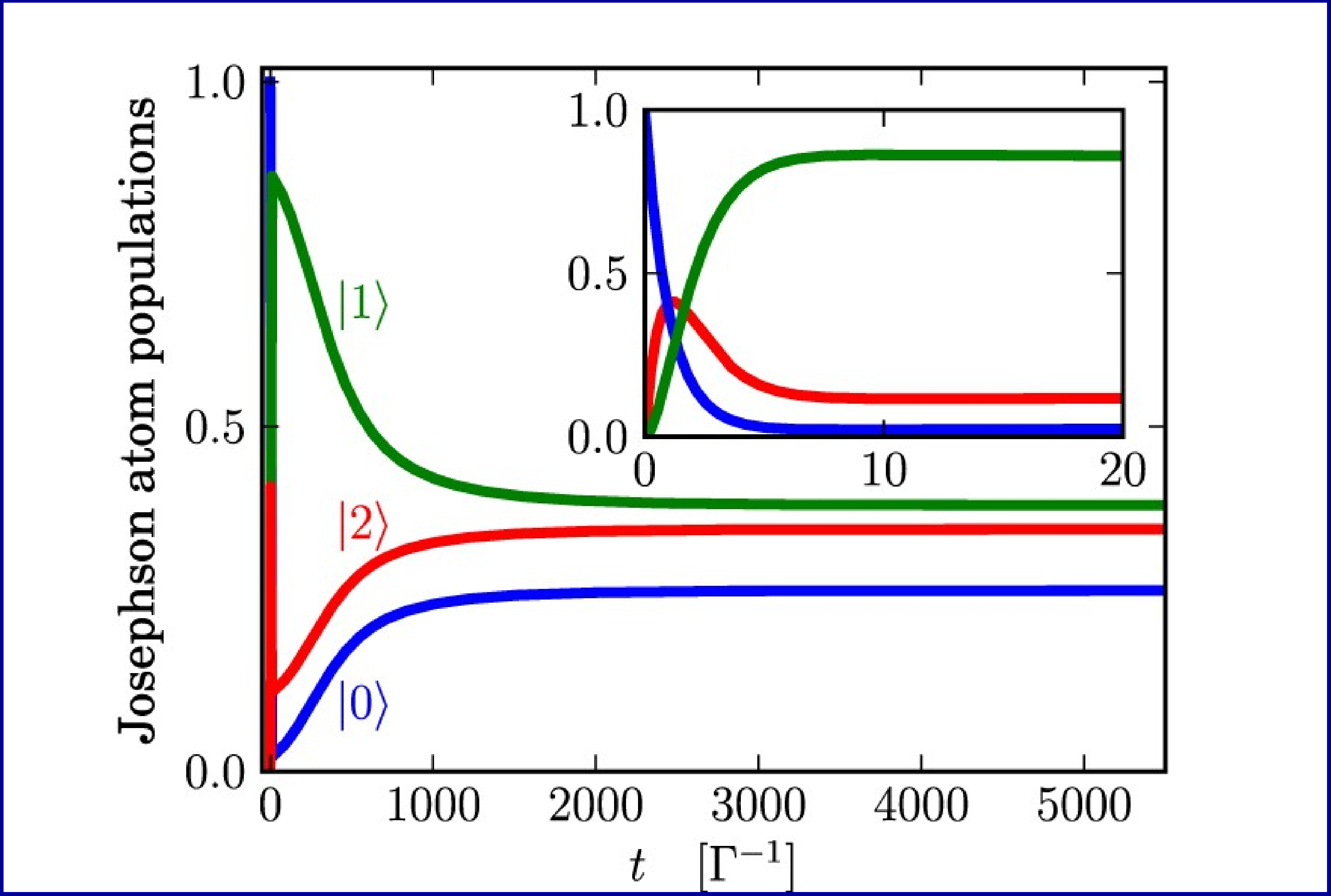
$$\hat{L}_{\gamma_{21}} = \frac{1}{2}\gamma_{21}\left(2\sigma_{21}\rho\sigma_{12} - \sigma_{11}\rho - \rho\sigma_{11}\right), \quad \sigma_{ij} = |i\rangle\langle j|$$

$$\hat{L}_{\kappa} = \frac{1}{2}\kappa\left(2\hat{a}\rho\hat{a}^{\dagger} - \hat{a}^{\dagger}\hat{a}\rho - \rho\hat{a}^{\dagger}\hat{a}\right)$$

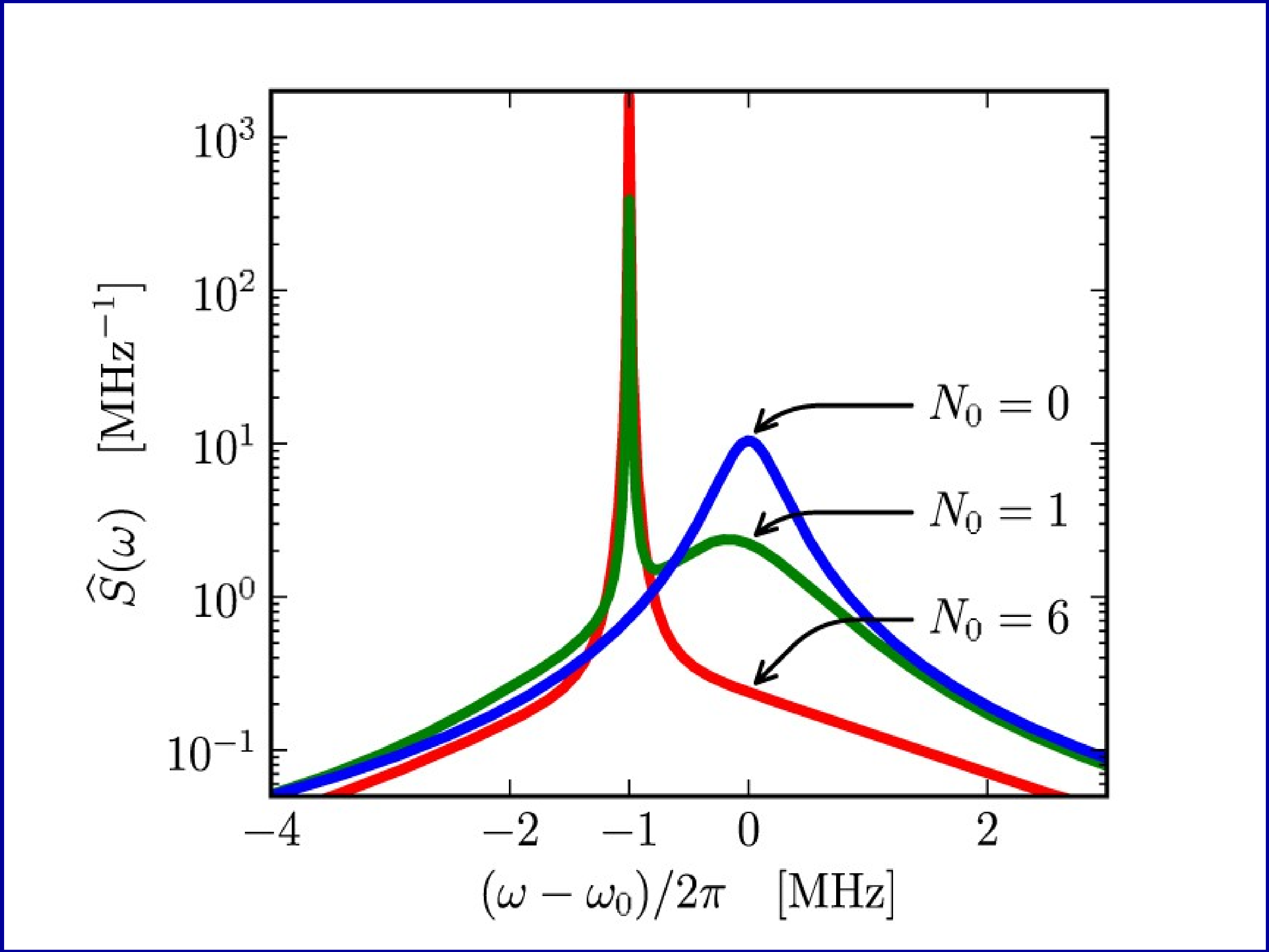
Transient dynamics – Cavity



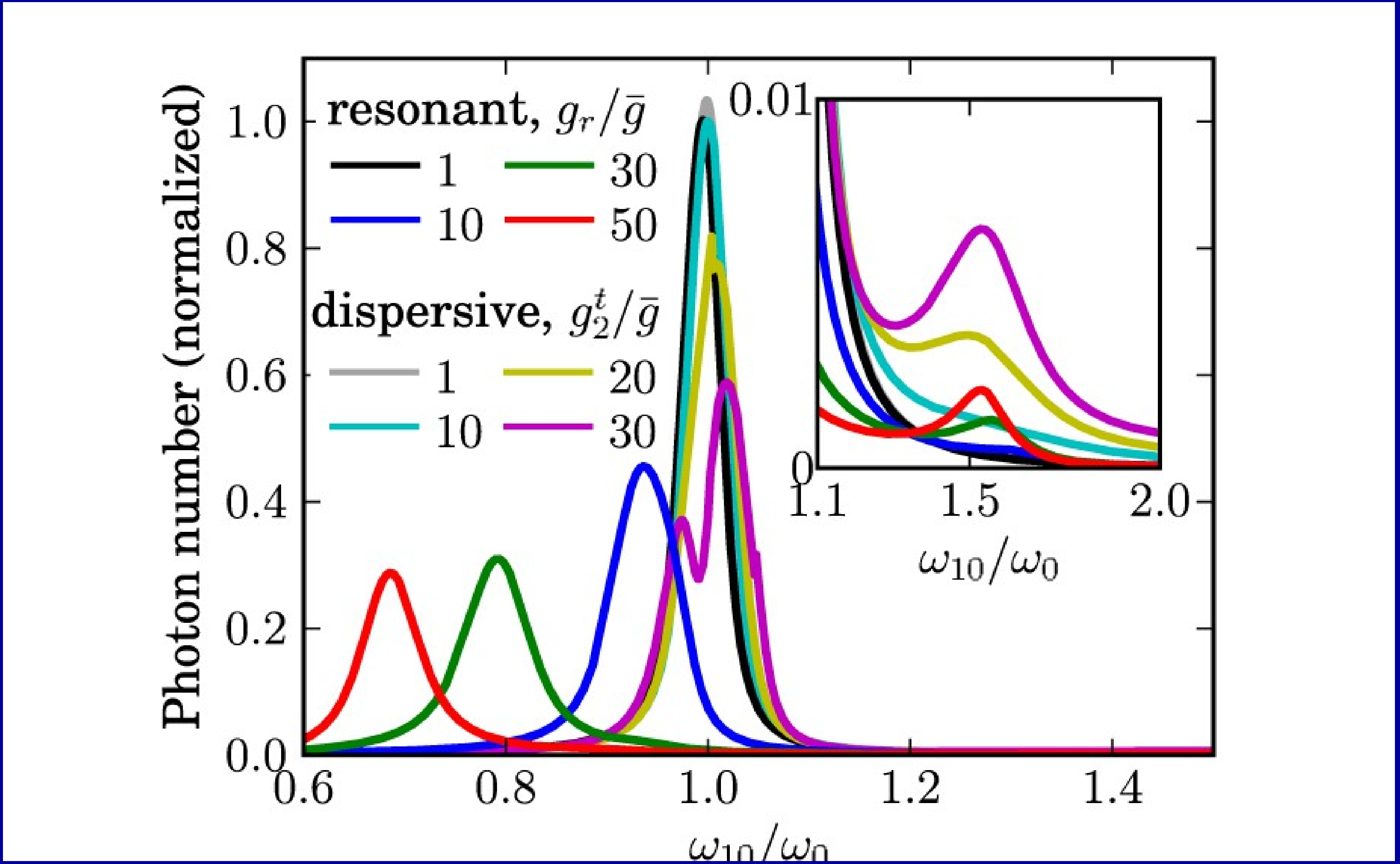
Transient dynamics – Qubit



Driven cavity

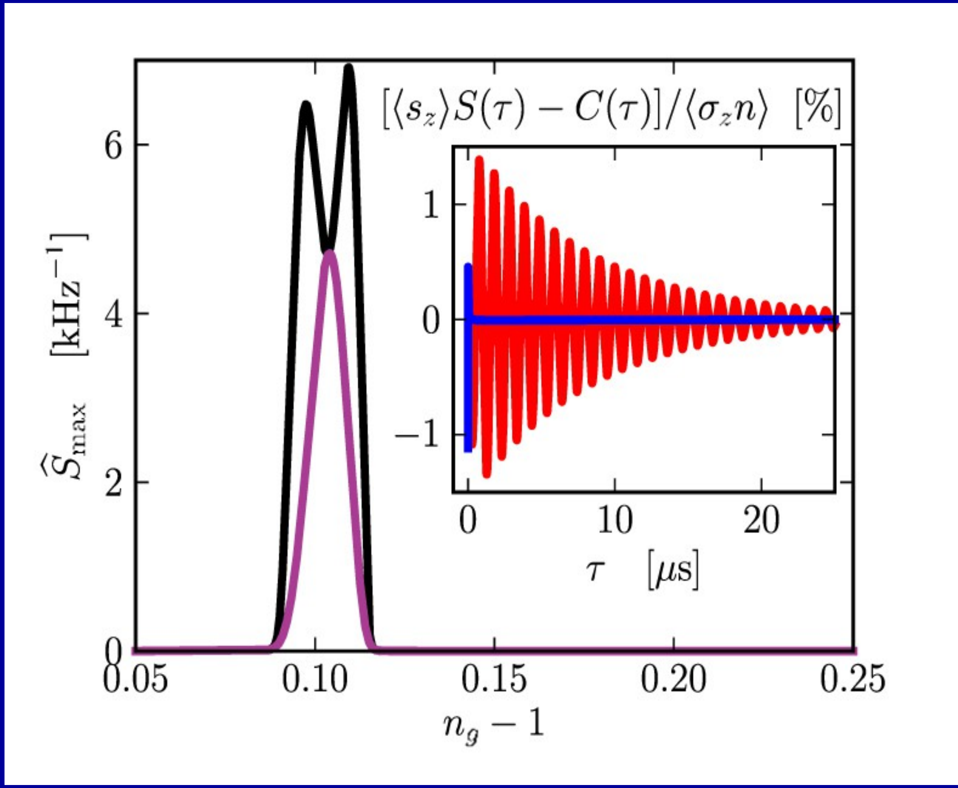


Coupling to a two-level system



Semi-classical approximation

$$\langle \sigma_z \hat{a}^\dagger \hat{a} \rangle \approx \langle \sigma_z \rangle \langle \hat{a}^\dagger \hat{a} \rangle$$



Fails close to the resonance

Conclusions

- The Lindblad equation fully describes the dynamics of an artificial atom
- The additional peak can be due a coupling to a two-level system
- Semi-classical approximation fails close to the resonance