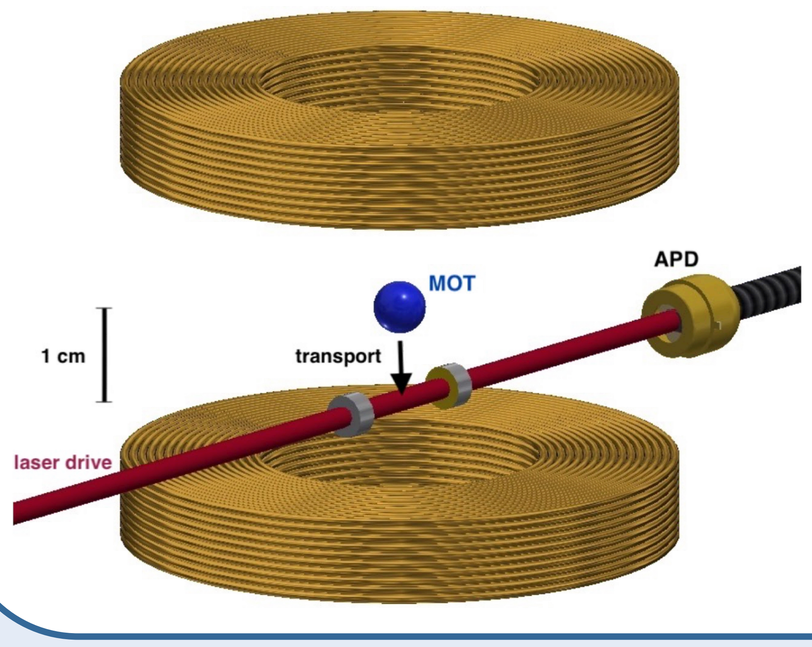
Wigner 121
Scientific Symposium

Wigner Research Centre for Physics
Institute for Solid State Physics and Optics
Quantum Optics and Quantum Information
Quantum Optics "Momentum" Group

Cold atom cavity QED experiment



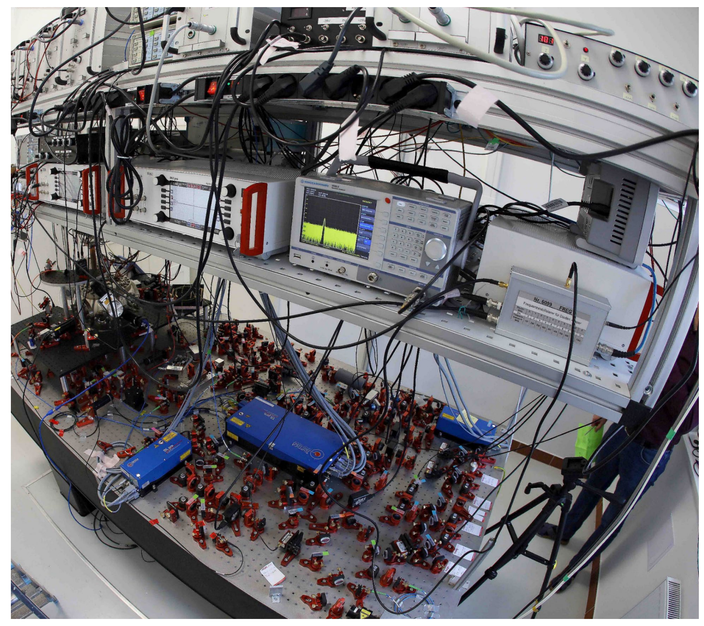
Experimental system

- laser-cooled ^{87}Rb atoms in a magneto-optical trap
- T = 100 μK
- optical pumping into the $(F, m_F) = (2, 2)$ state
- loading the atoms into a magnetic quadrupole trap
- transport into the cavity

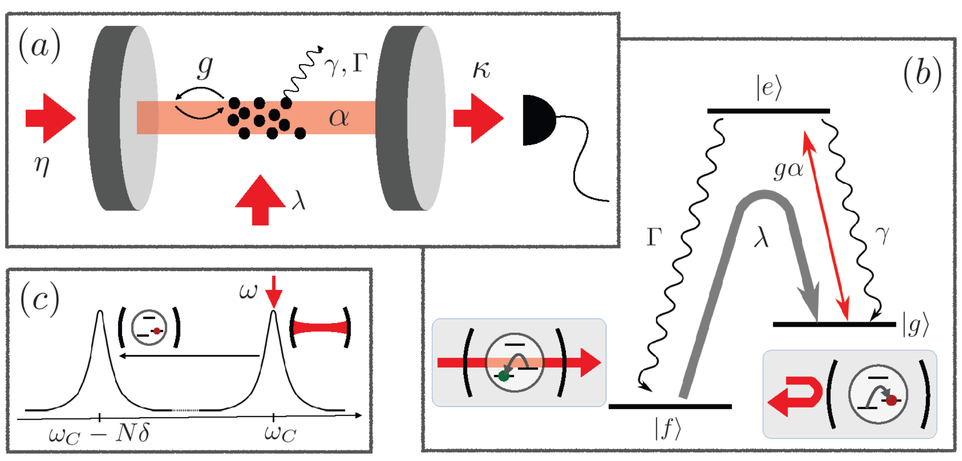
Cavity QED parameters

- cavity length 15mm, mode waist 127 μm
- photon loss rate $\kappa = 2\pi \times 3.2$ MHz
- coupling strength $g = 2\pi \times 0.33$ MHz
- atomic linewidth $\gamma = 2\pi \times 3$ MHz

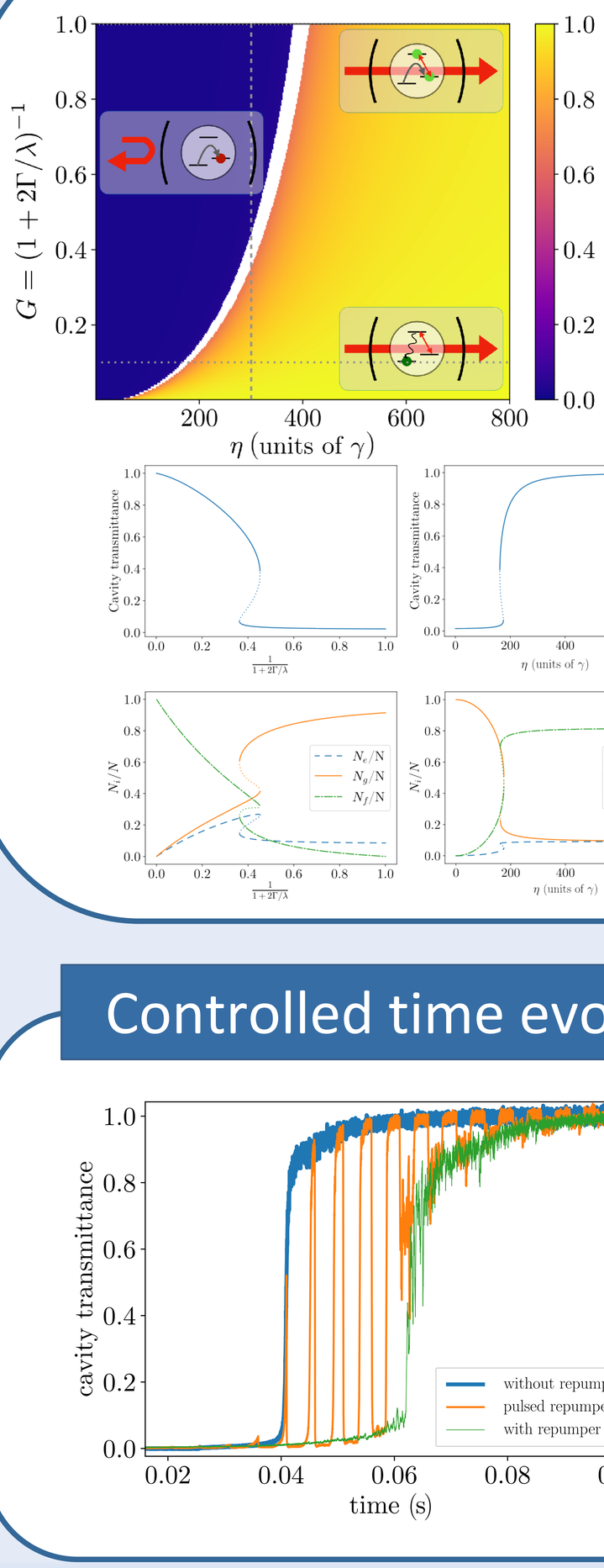
Collective strong coupling $\mathcal{C} = \frac{Ng^2}{\gamma\kappa} > 100$



Competing pumps



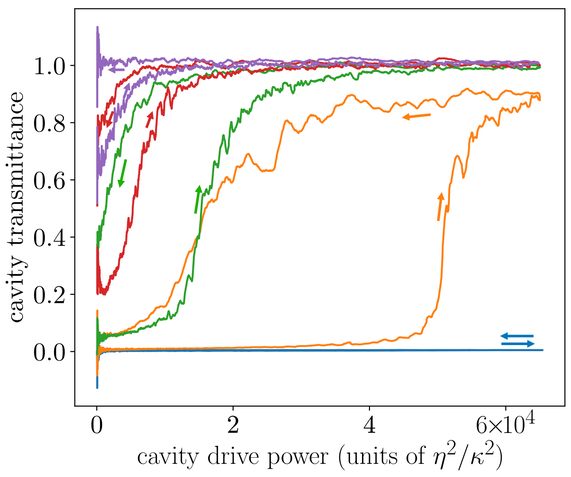
Phase diagram



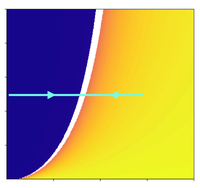
Mean-field model

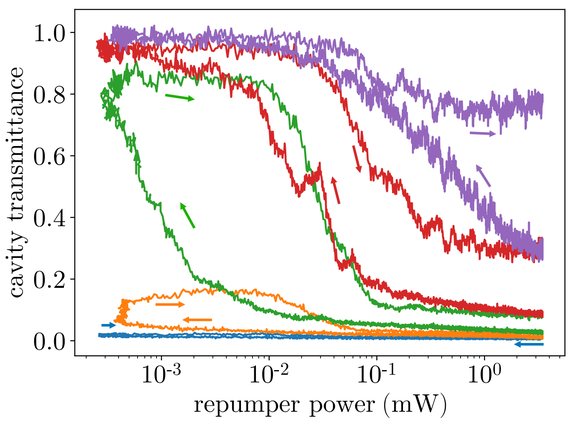
$$\dot{\alpha} = (i\Delta_C - \kappa)\alpha + gM + \eta,$$
$$\dot{M} = (i\Delta_A - \gamma - \Gamma)M + g(N_e - N_g)\alpha,$$
$$\dot{N}_e = -g(\alpha^* M + M^* \alpha) - 2(\gamma + \Gamma)N_e,$$
$$\dot{N}_g = g(\alpha^* M + M^* \alpha) + 2\gamma N_e + \lambda N_f,$$
$$\dot{N}_f = 2\Gamma N_e - \lambda N_f.$$

Hysteresis

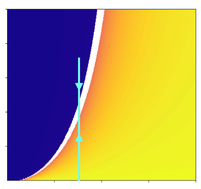


- bistable switching between ground states $|g\rangle \leftrightarrow |f\rangle$
- bistable region shrinks due to atom loss





- ramping up then down the laser drives 5 times
- first-order phase transition with hysteresis



Controlled time evolution

- switching between phases
- repumper ON → $|g\rangle$ – dark
- repumper OFF → $|f\rangle$ – bright
- slope of drop – fitting λ

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