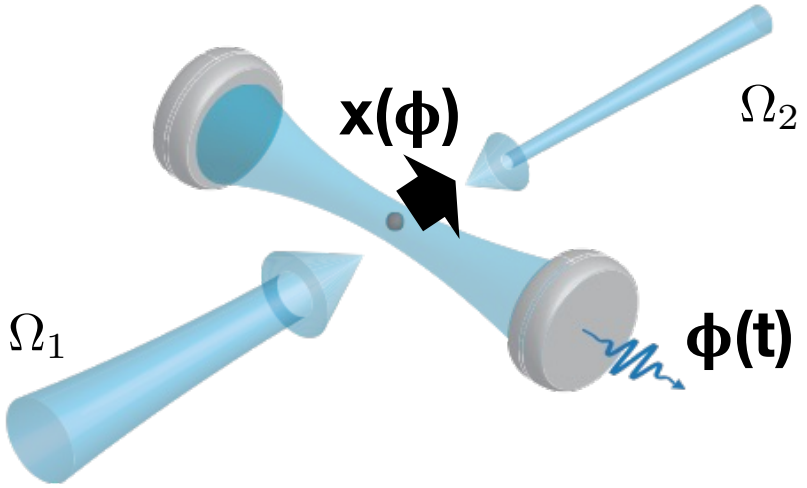


Self-oscillating pump in a topological dissipative atom-cavity system

Davide Dreon, Alexander Baumgärtner, Xiangliang Li, Simon Hertlein, Tilman Esslinger and Tobias Donner

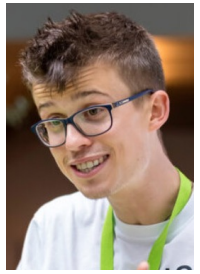
ETH zürich

arXiv:2112.11502 (2021)
Nature 608.7923 (2022): 494-498

The Team



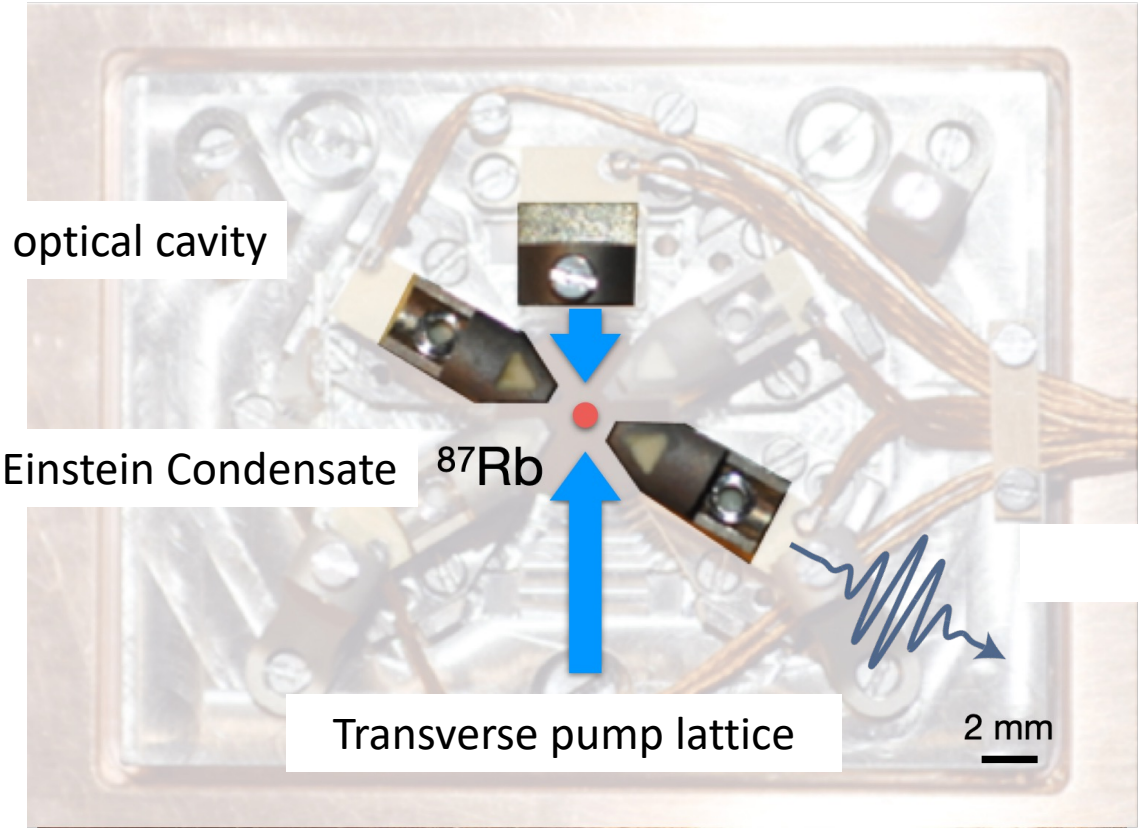




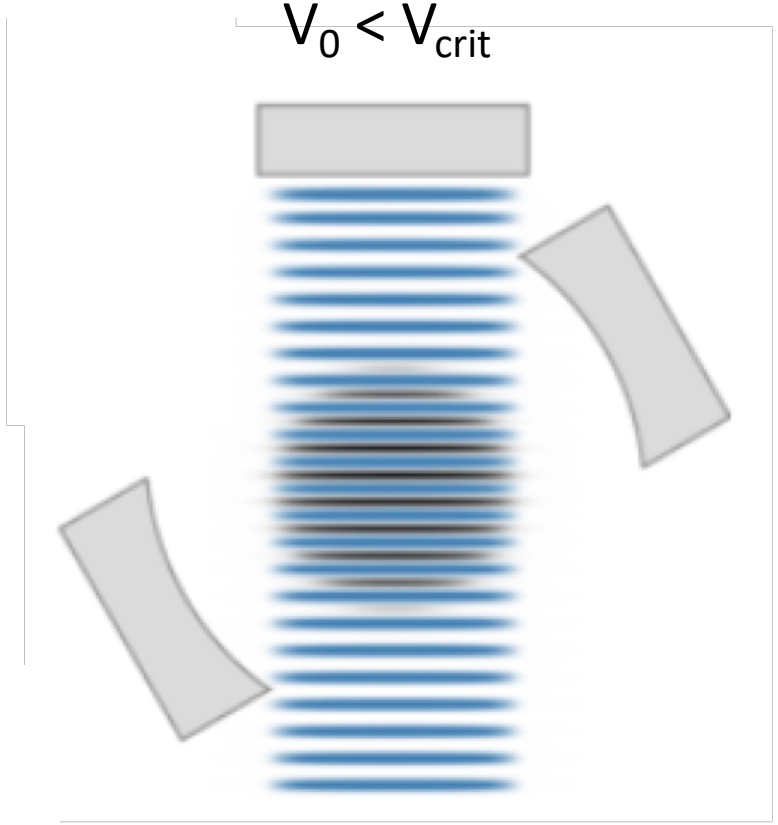

The current teams:
Crossed cavities:
Alexander Baumgärtner, Simon Hertlein, Justyna Stefaniak, Dalila Rivero, Tobias Donner, Tilman Esslinger

Former group members contributing:
Andrea Morales, Philip Zupancic, Davide Dreon, Carlos Maximo

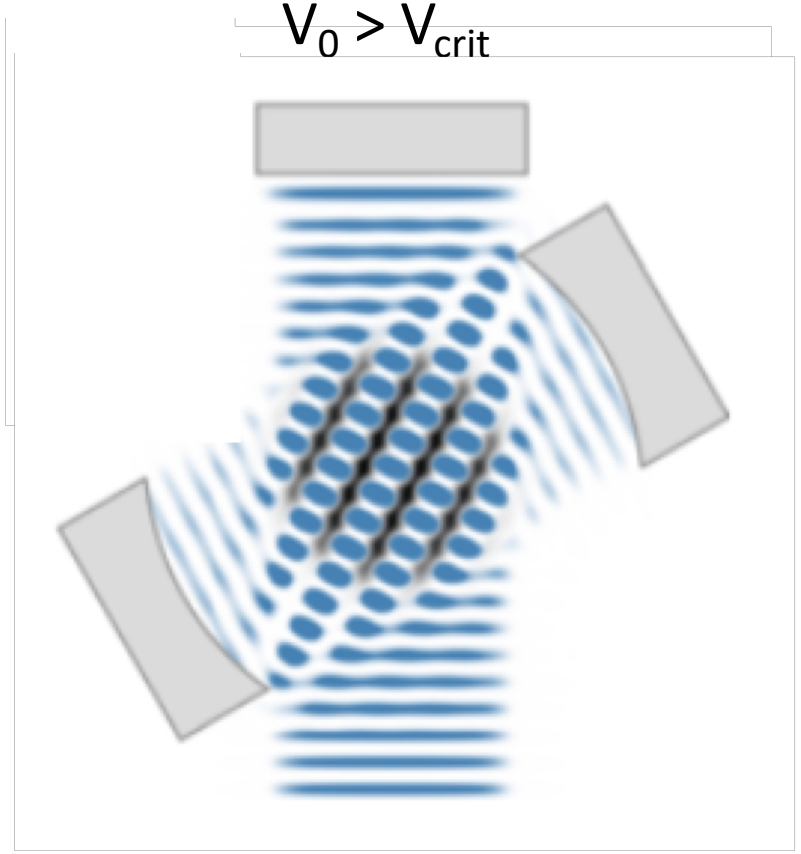
Our experiment: A BEC in a high-finesse cavity



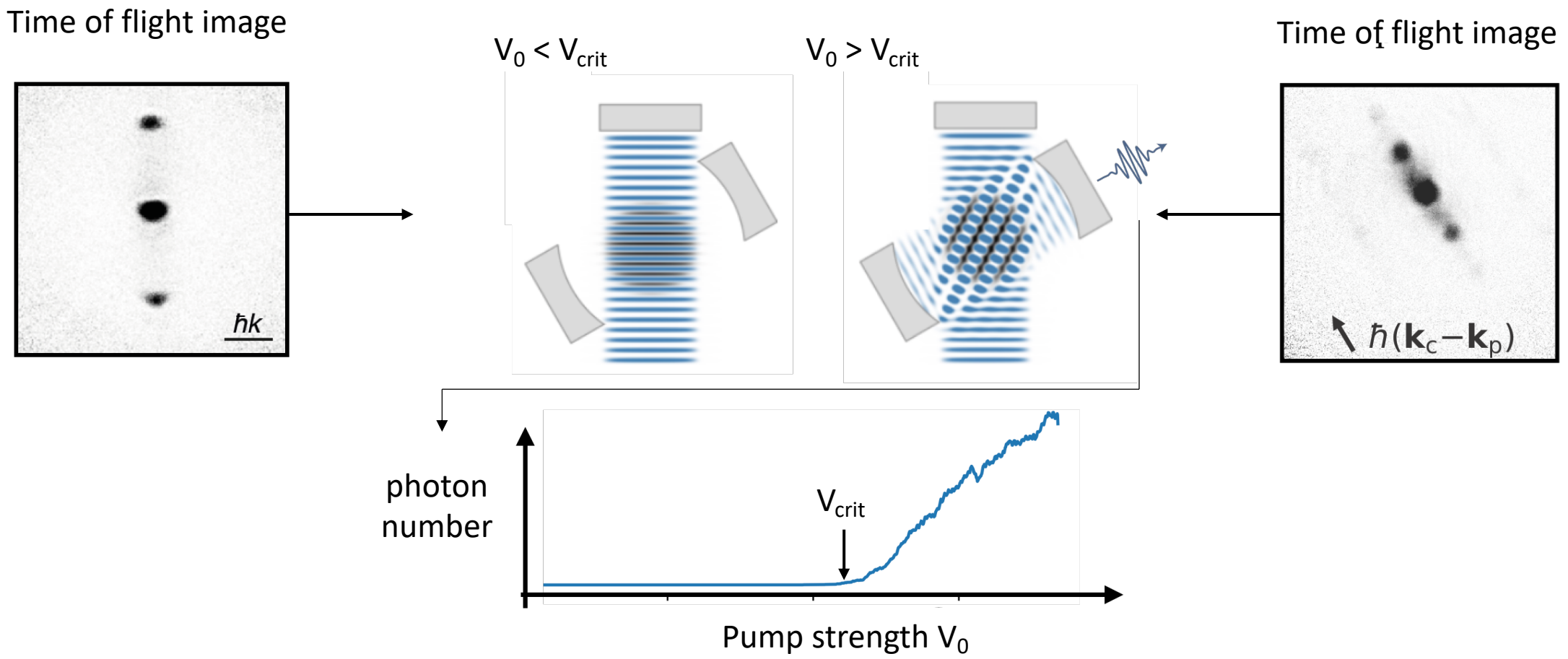
A BEC in a cavity



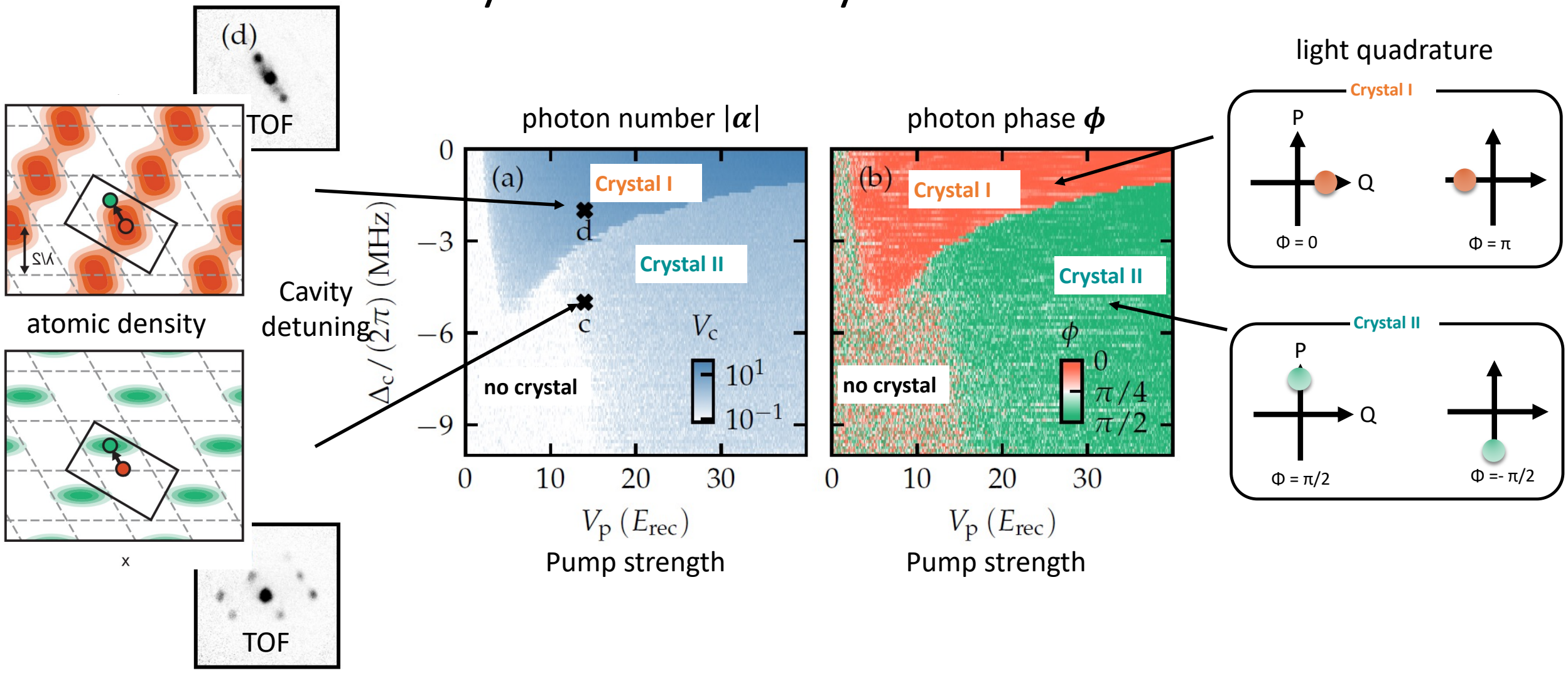
Phase transition



Phase transition

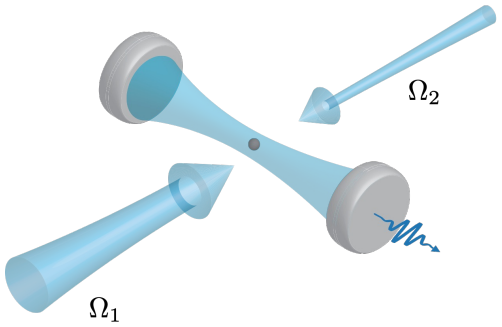


Two centrosymmetric crystals



Li *et al.* , PRR 2021

Single particle Hamiltonian



Kinetic energy

Pump lattice

Cavity lattice

Cavity photon energy

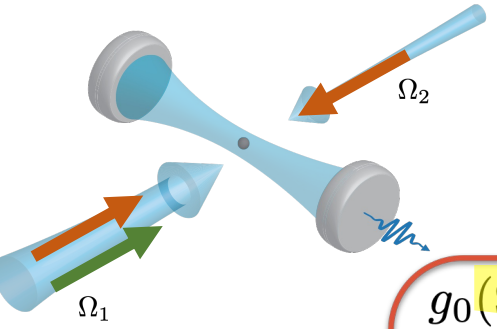
$$\hat{\mathcal{H}}/\hbar = \frac{\mathbf{p}^2}{2m\hbar} + \frac{\Omega_1\Omega_2}{\Delta_a}\cos^2(\mathbf{k}_p\mathbf{r}) + \frac{g_0^2}{\Delta_a}\cos^2(\mathbf{k}_c\mathbf{r})\hat{a}^\dagger\hat{a} - \Delta_c\hat{a}^\dagger\hat{a}$$

Two interference lattices

$$\frac{g_0(\Omega_1+\Omega_2)}{\Delta_a}(\hat{a}^\dagger+\hat{a})\cos(\mathbf{k}_p\mathbf{r})\cos(\mathbf{k}_c\mathbf{r}) + i\frac{g_0(\Omega_1-\Omega_2)}{\Delta_a}(\hat{a}-\hat{a}^\dagger)\sin(\mathbf{k}_p\mathbf{r})\cos(\mathbf{k}_c\mathbf{r})$$

Li *et al.* , PRR 2021

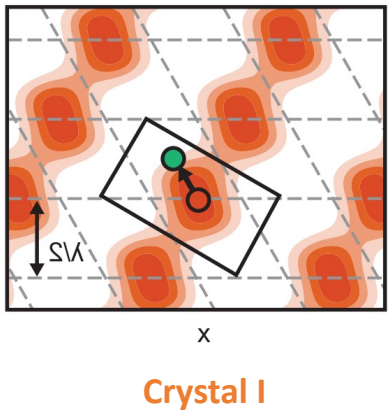
Two centrosymmetric crystals – atomic densities



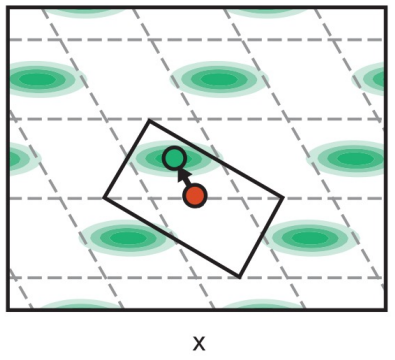
Two interference lattices

$$\frac{g_0(\Omega_1+\Omega_2)}{\Delta_a}(\hat{a}^\dagger+\hat{a})\cos(\mathbf{k}_p\mathbf{r})\cos(\mathbf{k}_c\mathbf{r}) + i\frac{g_0(\Omega_1-\Omega_2)}{\Delta_a}(\hat{a}-\hat{a}^\dagger)\sin(\mathbf{k}_p\mathbf{r})\cos(\mathbf{k}_c\mathbf{r})$$

atomic density



Crystal I



Crystal II

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Two centrosymmetric crystals – light quadratures

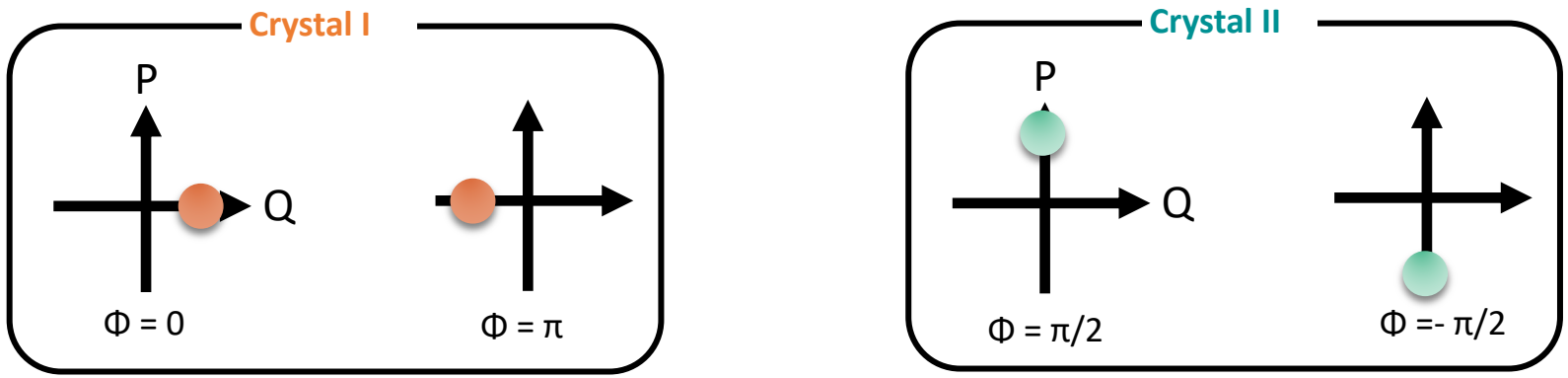
Two orthogonal light quadratures

$$\frac{g_0(\Omega_1+\Omega_2)}{\Delta_a}(\hat{a}^\dagger+\hat{a})\cos(\mathbf{k}_p\mathbf{r})\cos(\mathbf{k}_c\mathbf{r}) + i\frac{g_0(\Omega_1-\Omega_2)}{\Delta_a}(\hat{a}-\hat{a}^\dagger)\sin(\mathbf{k}_p\mathbf{r})\cos(\mathbf{k}_c\mathbf{r})$$

$\mathbb{R}\mathrm{e}\{\alpha\}$ $\mathbb{I}\mathrm{m}\{\alpha\}$

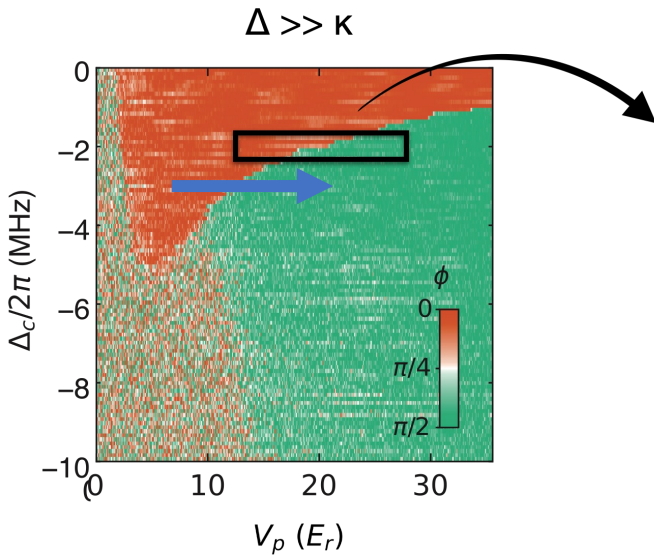
photons

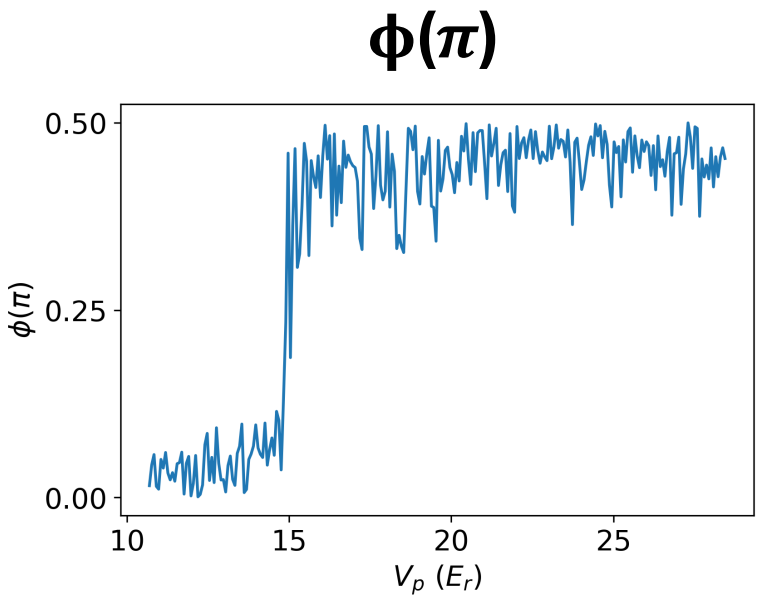
$\boldsymbol{\alpha = |\alpha| e^{-i\phi}}$

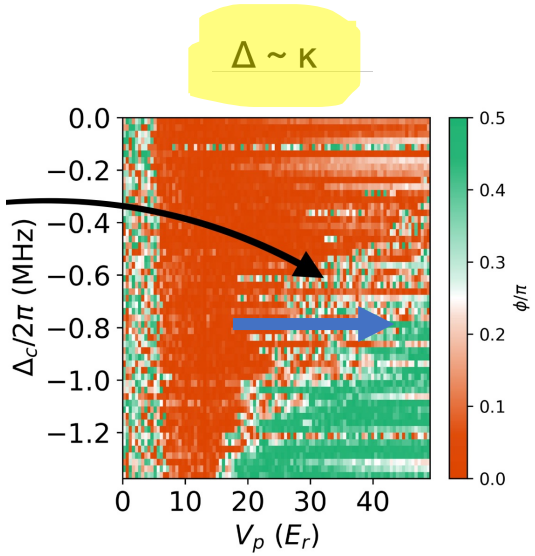


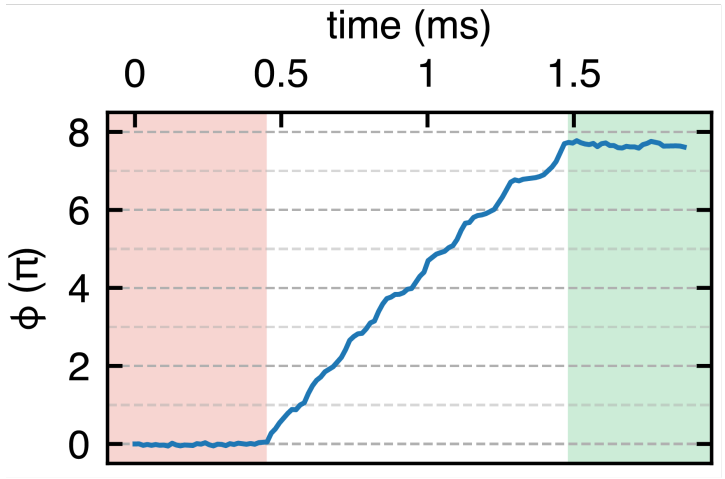
Li *et al.* , PRR 2021

Phase diagram + dissipation





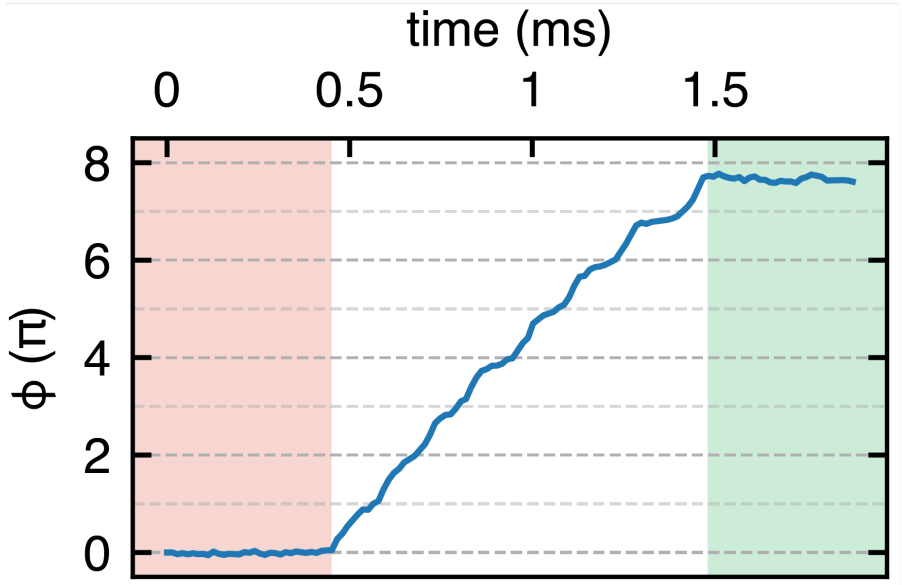




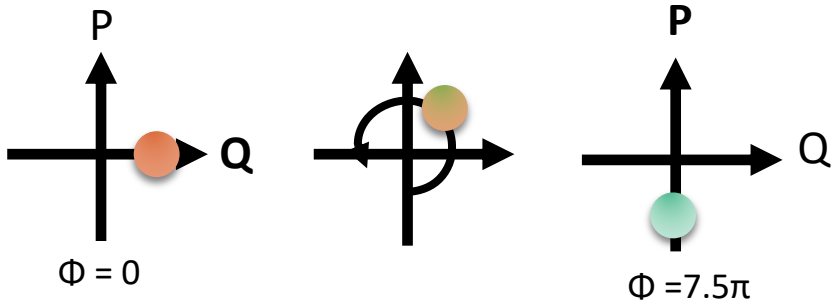
Dreon *et al.* , Nature 2022

Dissipation induced dynamics – photonic part

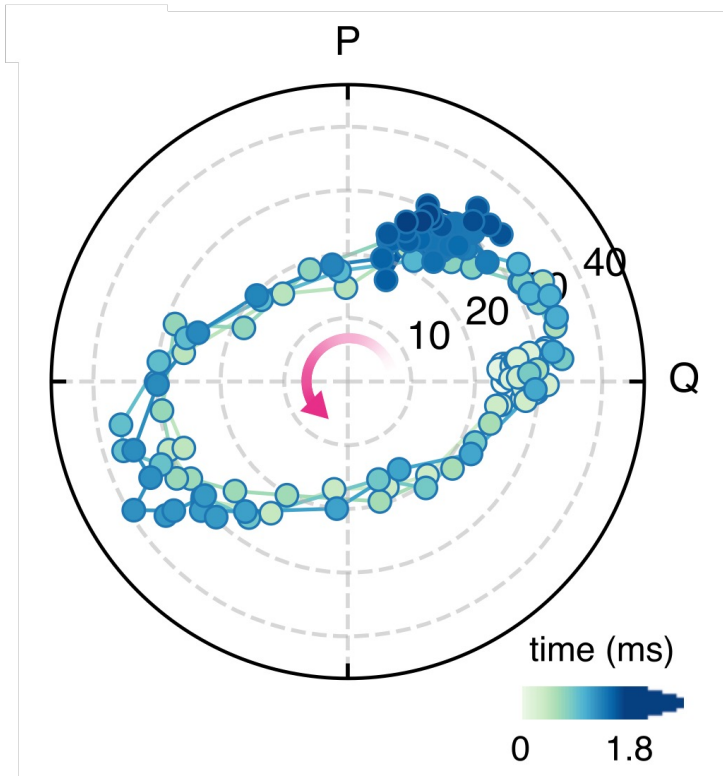
photon phase



light quadrature

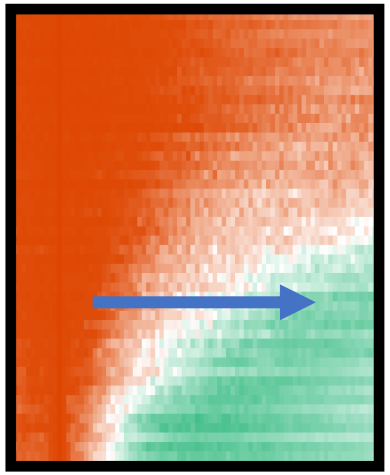


Measured optical phase space

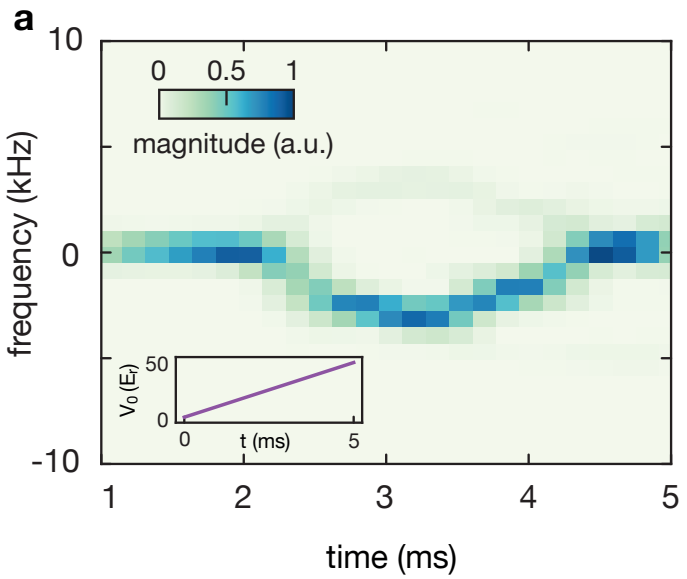


Dreon *et al.* , Nature 2022

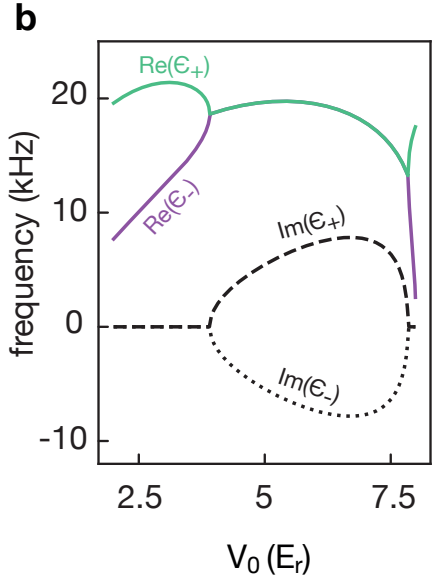
Dissipation induced dynamics – photonic part



Heterodyne spectrum develops frequency sideband

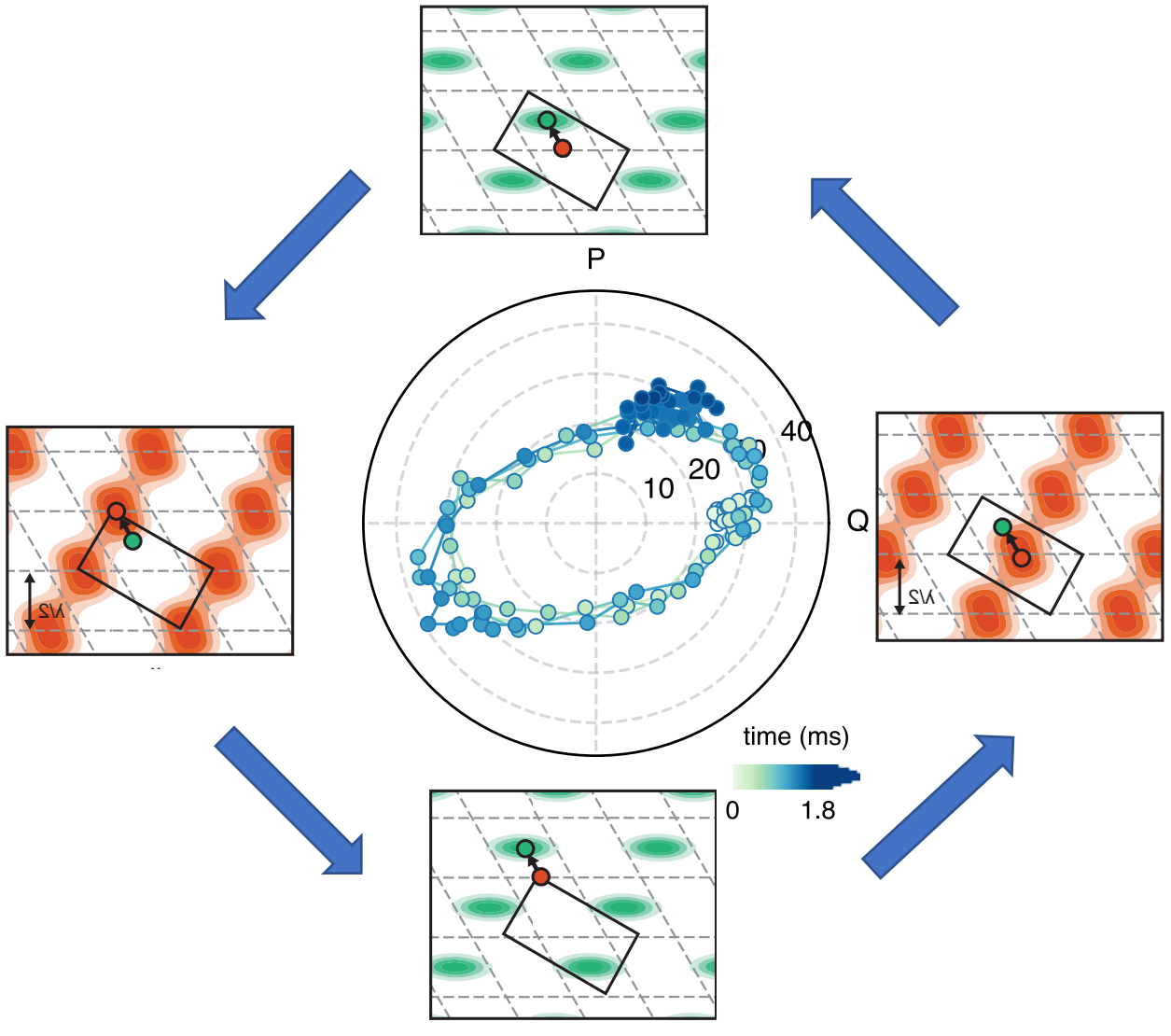


Solving the mode energy spectrum of a truncated Hamiltonian

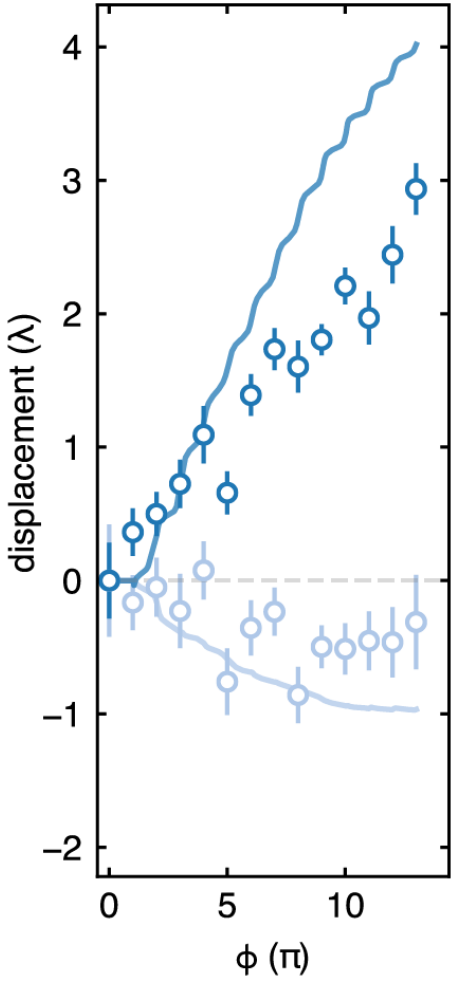


Dreon *et al.* , Nature 2022

Self-consistent pump



Measuring atomic displacement *in-situ*



Dreon *et al.* , Nature 2022

Summary

1. Interface of two lattices/crystals with different lattice geometries/symmetries
   Li *et al*. , PRR 2021
2. Dissipation driven pump between those topological non-trivial lattices
   Dreon *et al.,* Nature 2022