MOLecuLAR lattice quantum electrodynamics (MOLAR)

Partners and team

https://molar.fzu.cz

CSIC Consejo Superior de Investigaciones Científicas

Université de Lille — cnrs dépasser les frontières

CNR-INO Istituto Nazionale di Ottica, Consiglio Nazionale delle Ricerche

Czech Academy of Sciences





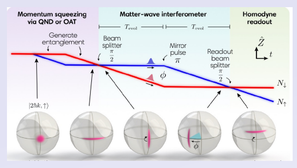

A. González-Tudela A. Gómez-León A. Amo C. Toninelli M. Colautti T. Neuman

Motivation: Light-matter interfaces are a cornerstone of quantum science and technology

Computation & Simulation

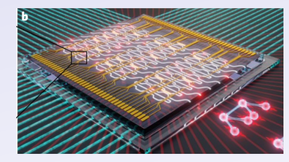
Nature **626**, 58 (2024); Nature **595**, 233 (2021);

Metrology & sensing



Nature **610**, 472 (2022);

Communication

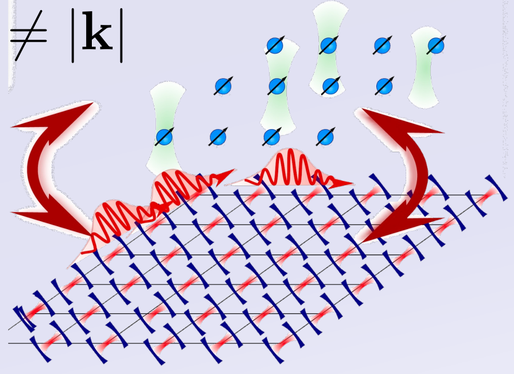


Nature Nano **16**, 1308 (2021)

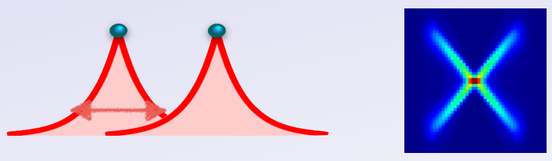
Challenge: require strong, versatile, scalable interactions

Novel approach: Lattice quantum electrodynamics platforms, that are, emitters interacting with non-linearly dispersive photons can surpass the limitations of conventional platforms

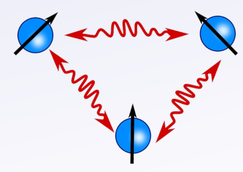
$\omega(\mathbf{k}) \neq |\mathbf{k}|$



Tunable & longer-ranged interactions



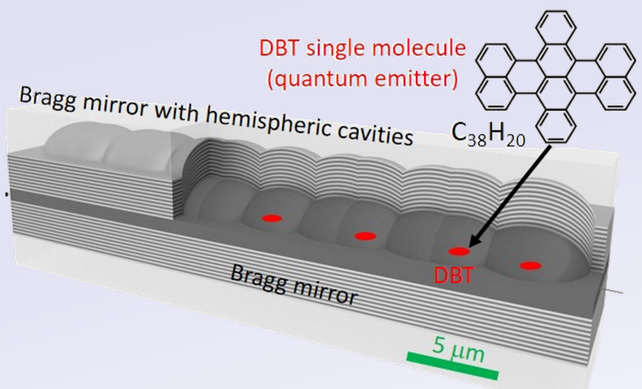
Stronger collective dissipation (super/subradiance)

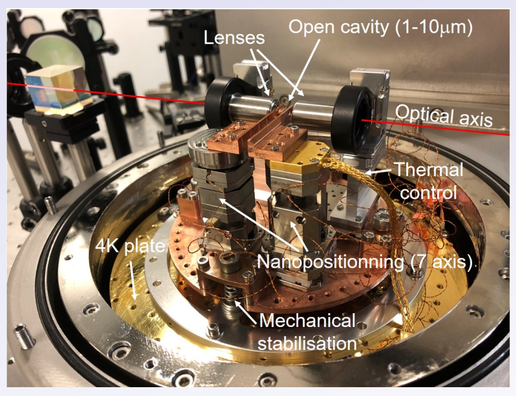


Targetted breakthrough: integrate, for the first time, molecular quantum emitters with dielectric photonic lattices embedded in an open cavity.

Molecular emitters

- "Identical"
- Deterministic positioning
- Small inhomogeneous broadening





Photonic structure

- High-Q
- Enhanced adressing & read-out

Objectives

- **Demonstration of the coupling of individual emitters to the photonic lattices**. This will be certified by measuring dynamical photoluminescence spectra and intensity second-order correlation measurements.
- **Observation of tunable-range localization in photonic band-gaps.** We aim at evidencing it first with single emitters, by directly monitoring the photonic population over the lattices, and then with many molecules by measuring the spectral signatures of the emergent photon-mediated interactions.
- **Demonstration of the molecular collective dissipative phenomena**. We target to visualise the emergence of perfect light localization in one and two dimensions due to perfect subradiance. This will be done by monitoring the light emitted from the photonic lattices and the quenched spontaneous decay dynamics.