Room-Temperature Polariton Supersolids

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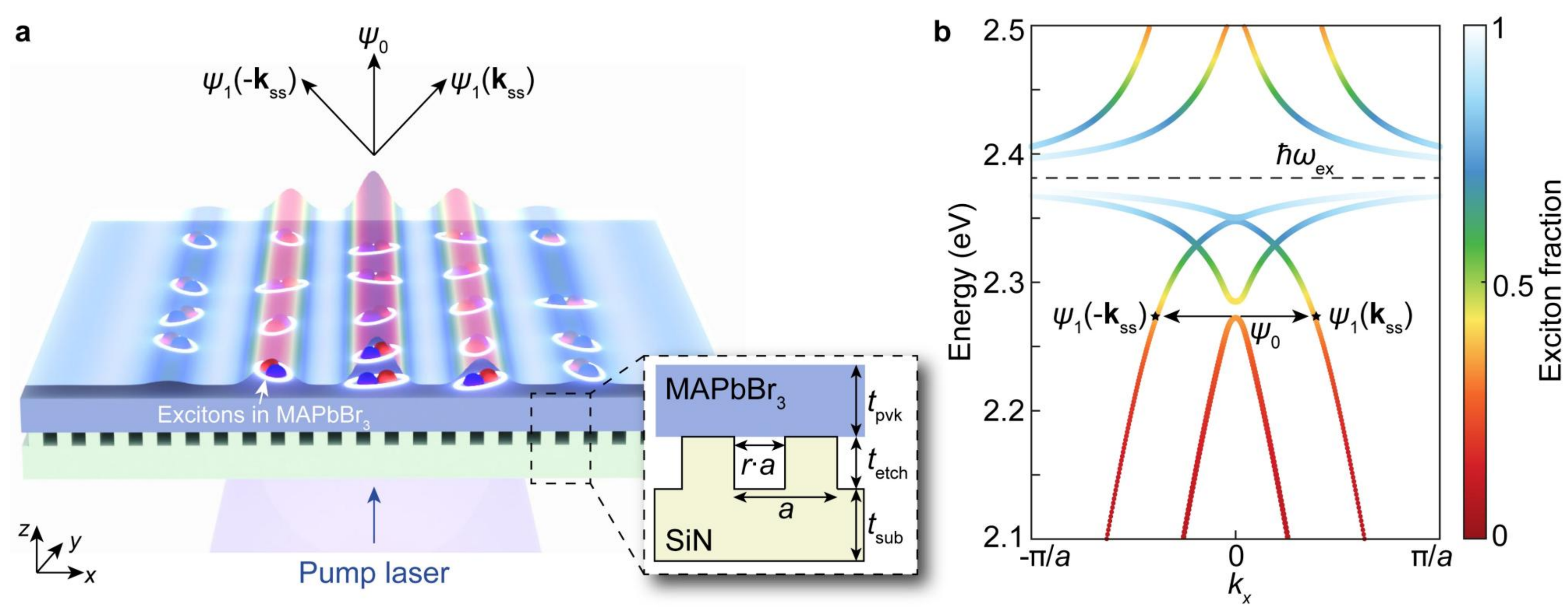
1. Background & Significance

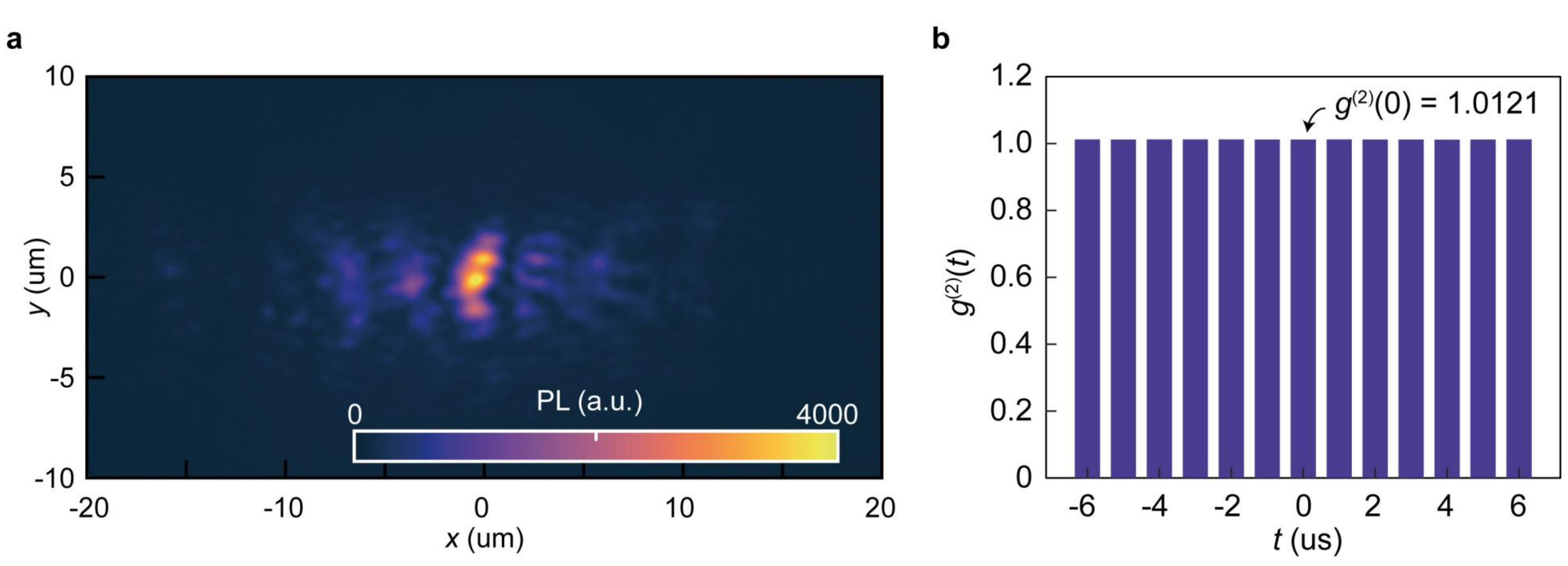
- Supersolids combine two hallmark orders in one quantum phase: crystalline density modulation (DLRO) and global phase coherence/ frictionless flow (ODLRO).
- Previous demonstrations were limited to ultracold atoms or cryogenic III–V polariton systems.
- A room-temperature supersolid would provide a practical platform for quantum many-body physics, hydrodynamics, and on-chip coherent devices.
- This work reports the first room-temperature supersolid in a photonic-crystal polariton condensate.
- Key advance: room-temperature supersolidity enabled by a perovskite photonic-crystal platform.

2. Platform & Experimental Approach



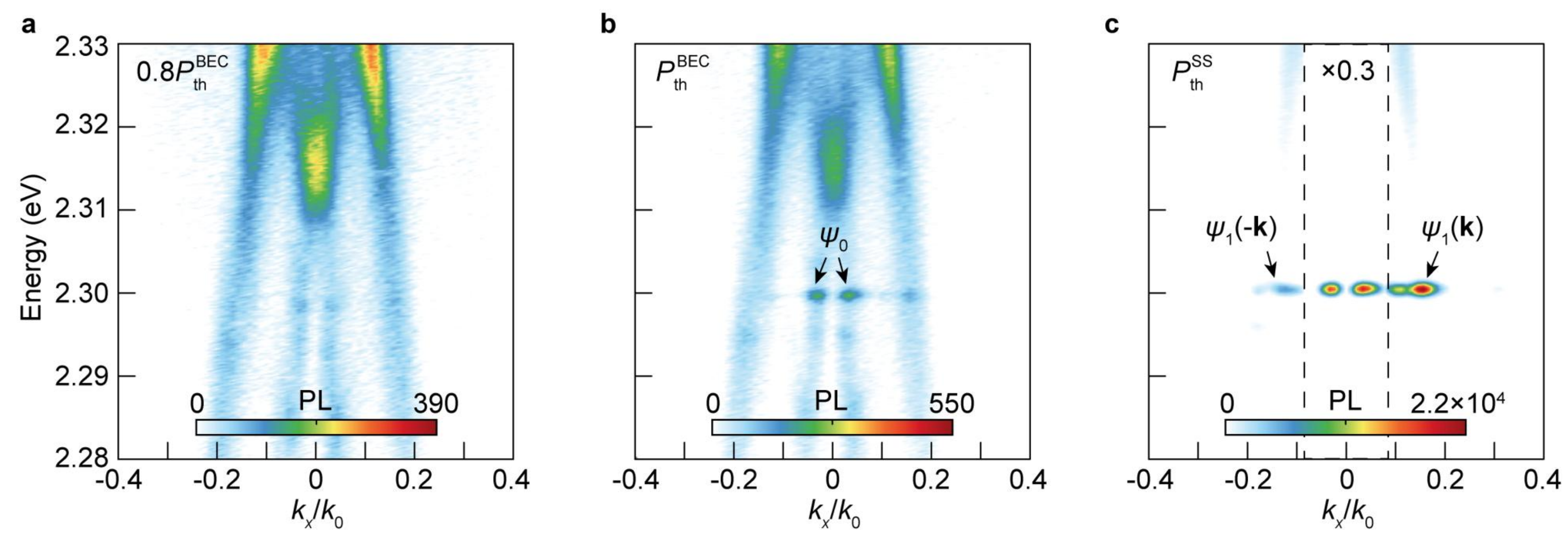
- Hybrid device: a $MAPbBr_3$ perovskite thin film integrated with a dispersion-engineered Si_3N_4 photonic-crystal waveguide.
- The structure supports a band-edge BIC condensate mode ψ_0 and a symmetric pair of first-order modes $\psi_1(\pm k)$.
- Strong nonlinear interactions and multi-mode dispersion enable parametric scattering from ψ_0 into $\psi_1(\pm k)$, driving supersolid formation.
- Excitation: femtosecond laser pump at 500 nm; momentum-space emission characterized by angle-resolved optical microscopy.
- Representative device parameters: t_{pvk} = 70 nm, t_{etch} = 50 nm, $t_{su\beta}$ = 200 nm, lattice constant a = 290 nm, filling factor r = 0.2.

5. Long-range orders of supersolids



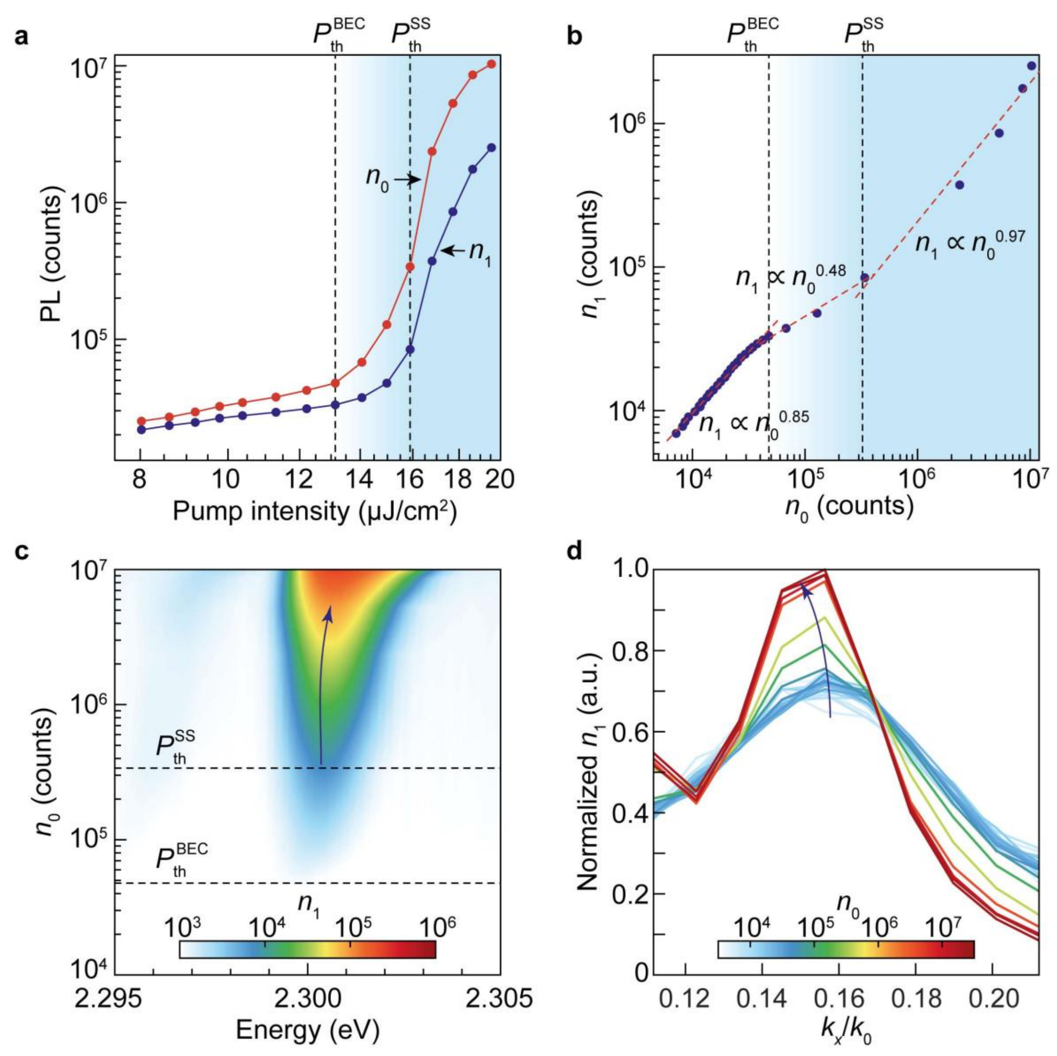
- Real-space imaging shows periodic density modulation: measured 3.33 μm, close to estimated 3.46 μm.
- HBT gives $g^2(0)$ = 1.0121 between $\pm k_{ss}$, demonstrating coherence between counter-propagating modes.
- Together, DLRO and ODLRO provide evidence of a room-temperature supersolid.

3. Momentum-Space Signatures



- Below threshold, broad spontaneous emission is observed.
- At the first threshold, P^{TBEc} = 13.14 μJ/cm², a sharp condensate forms in the high-Q BIC mode ψ_0.
- Above the second threshold, P^{Tss} = 15.89 μJ/cm², distinct peaks appear at finite momenta $\pm k_{ss}$, indicating macroscopic occupation of $\psi_1(\pm k_{ss})$.
- The emergence of these energy-degenerate counter-propagating modes marks spontaneous breaking of continuous translational symmetry.

4. Non-Rigid Supersolid Behavior



- Integrated intensities reveal sequential condensation and supersolid onset.
- The supersolid component density n_1 grows nonlinearly from the condensate density n_0, consistent with parametric scattering.
- As n_0 increases, interaction-induced blueshift changes the resonant wavevector k_{ss}.
- The shift of k_{ss} demonstrates a non-rigid supersolid with a tunable crystalline period.
- This behavior confirms that the density modulation is interaction-driven rather than a trivial lattice imprint.

6. Conclusions

We experimentally realize a room-temperature supersolid in a dispersion-engineered photonic-crystal polariton device. Above a critical condensation density, the interacting condensates spontaneously break the continuous translational symmetry via isoenergetic parametric scattering, creating a robust supersolid phase at room temperature. We further visualize the DLRO through realspace microscopy and verify ODLRO via momentum-space quantum coincidence measurements. This work establishes a practical platform for exploring the quantum hydrodynamics of supersolidity at room temperatures.