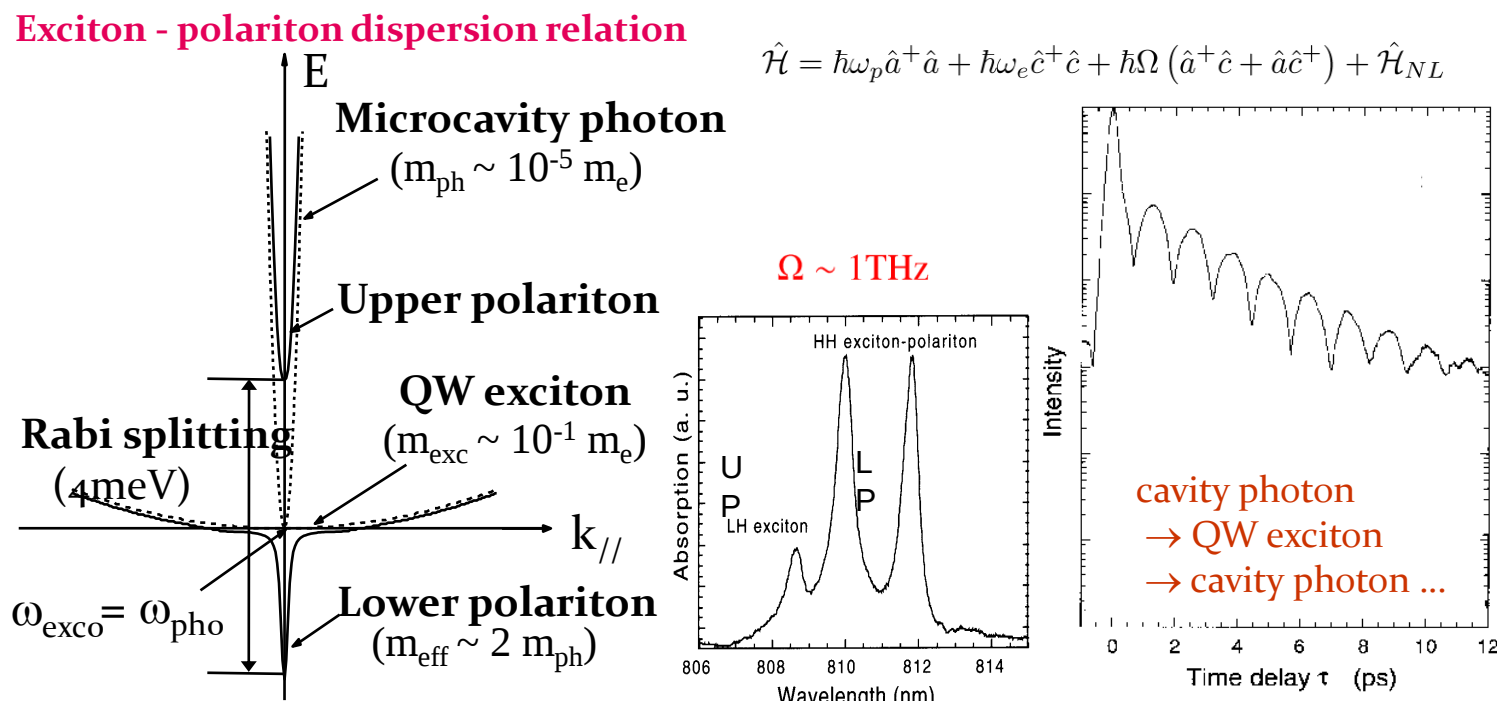


Dynamical Condensation of Exciton-Polaritons – New Quantum liquid and Application to Quantum Emulator –

S. Utsunomiya, H. Deng, C.W. Lai, G. Roumpos, M. Fraser, N. Masumoto and Y. Yamamoto
National Institute of Informatics, University of Tokyo, Stanford University

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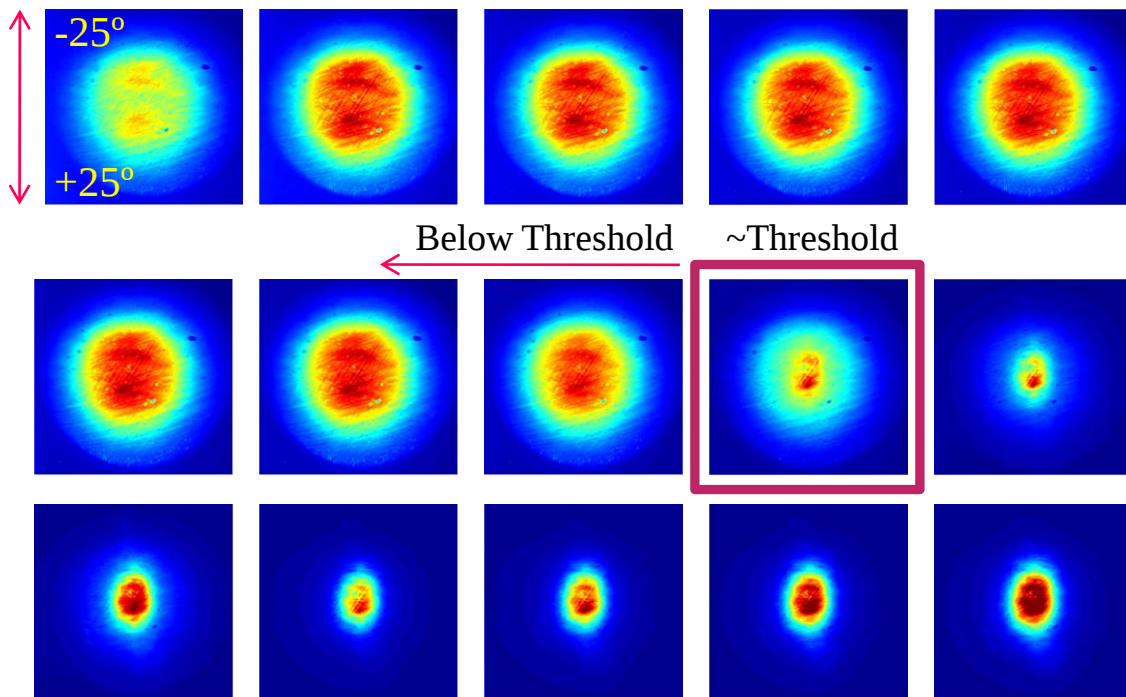
Semiconductor Cavity QED in Strong Coupling Regime – Dressing Excitons with Electromagnetic Vacuum Field –



C. Weisbuch et al., Phys. Rev. Lett. 69, 3314 (1992) S. Jiang et al., Appl. Phys. Lett. 73, 3031 (1998)

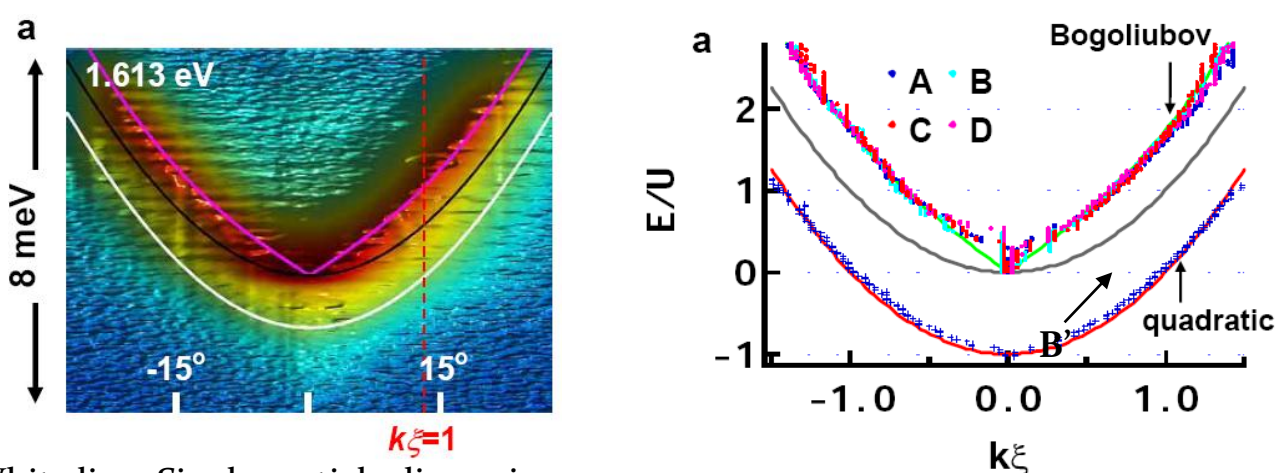
Far Field Pattern (momentum space distribution)

Thermal Polaritons $\rightarrow$ aspect ratio $\sim 1:1$ (isotropic) 50×50 degrees ($\Delta k = 7.5 \times 10^4 \text{ cm}^{-1}$)



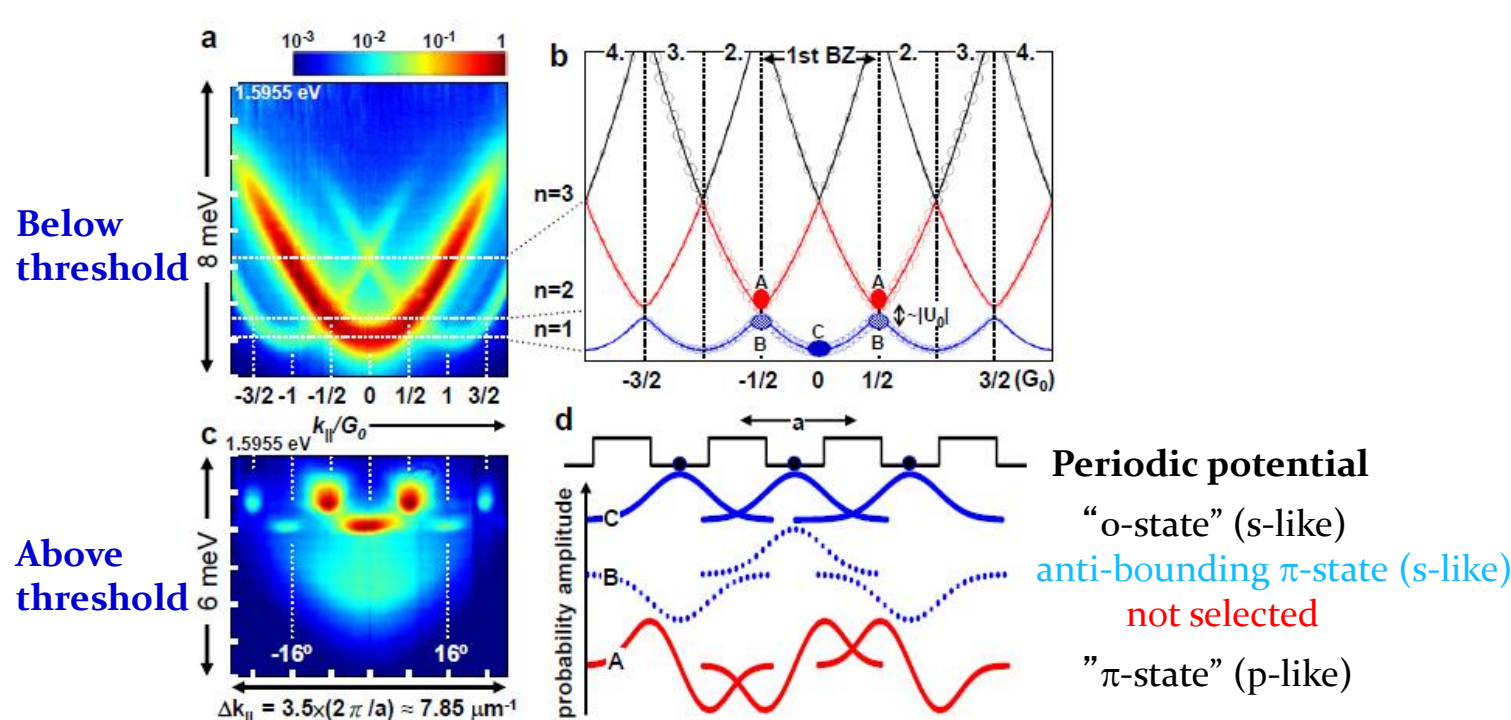
Bogoliubov Excitation Spectrum

S. Utsunomiya et al., to be published in Nature Physics



Bose-Hubbard model for exciton-polaritons in a one-dimensional periodic potential

C.W. Lai, et al., Nature 450, 529 (2007)



Condensation of Exciton-Polaritons

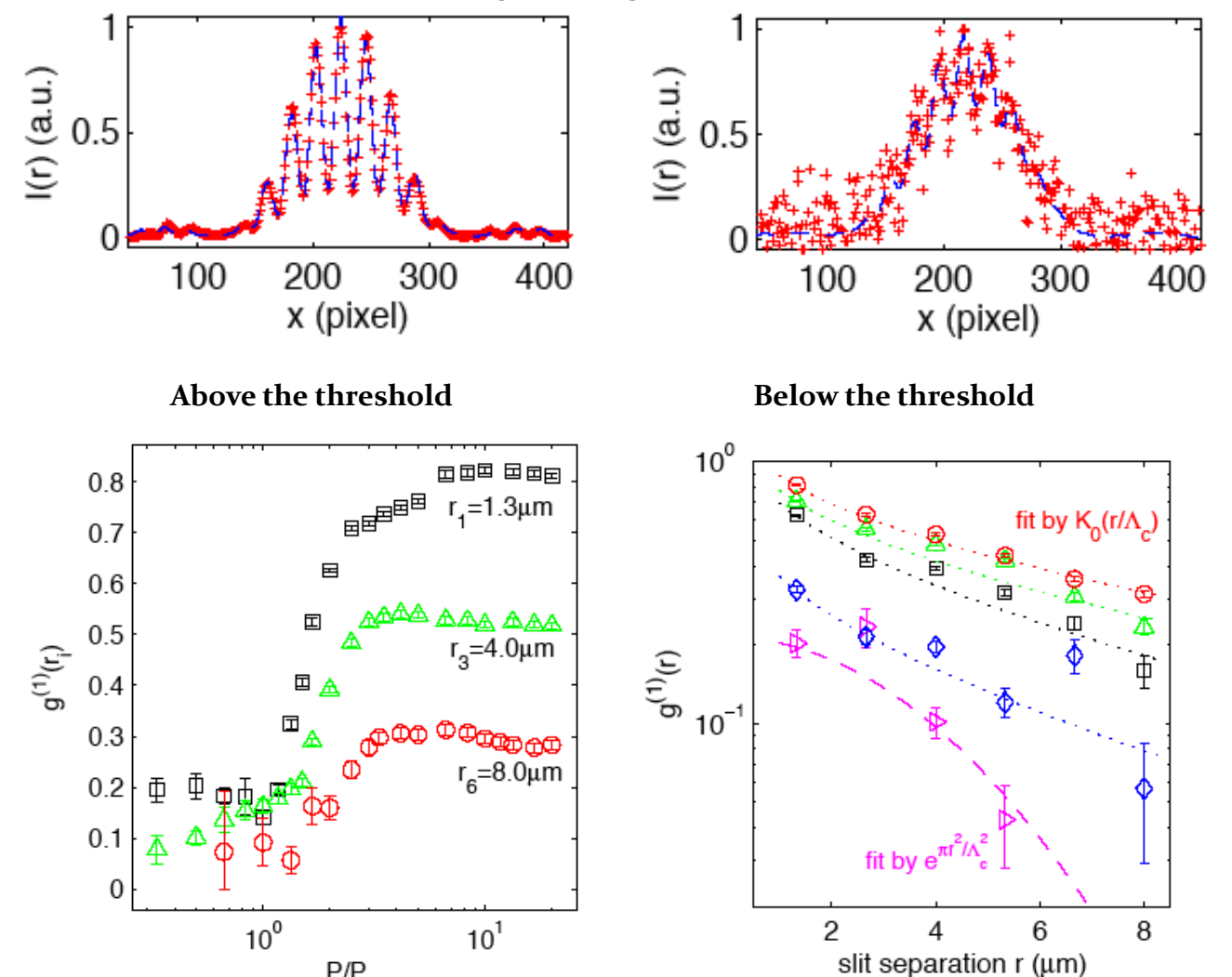
A. Imamoglu et al., Phys. Rev. A 53, 4250 (1996)

- Extended phase coherence reinforced by a cavity field
 $\Rightarrow$ suppressed localization, disorder and inhomogeneous broadening which are notorious enemies to exciton BEC.
- Light effective mass by dressing with a cavity field
 $m_{\text{polariton}} \sim 10^{-4} m_{\text{exciton}} \sim 10^{-8} m_{\text{atom}}$
 $n\lambda_T^3 = n \left(\frac{2\pi\hbar^2}{mk_B T_c} \right)^{3/2} \sim 2.62 \Rightarrow$ higher critical temperature ($\gtrsim 10^4 T_{\text{exc}} \sim 10^8 T_{\text{atom}}$)
lower particle density ($\lesssim 10^{-6} n_{\text{exc}} \sim 10^{-12} n_{\text{atom}}$)
 $\Rightarrow$ suppressed dissociation of excitons
- Main decay channel = Photon leakage from the cavity with k and E conservation
 $\Rightarrow$ direct experimental access to polariton energy-momentum dispersion and population distribution

Off Diagonal Long Range Order (Spatial Coherence)

H. Deng et al., Phys. Rev. Lett. 99, 126403 (2007)

Interference Pattern through Young's Double Slit Interferometer

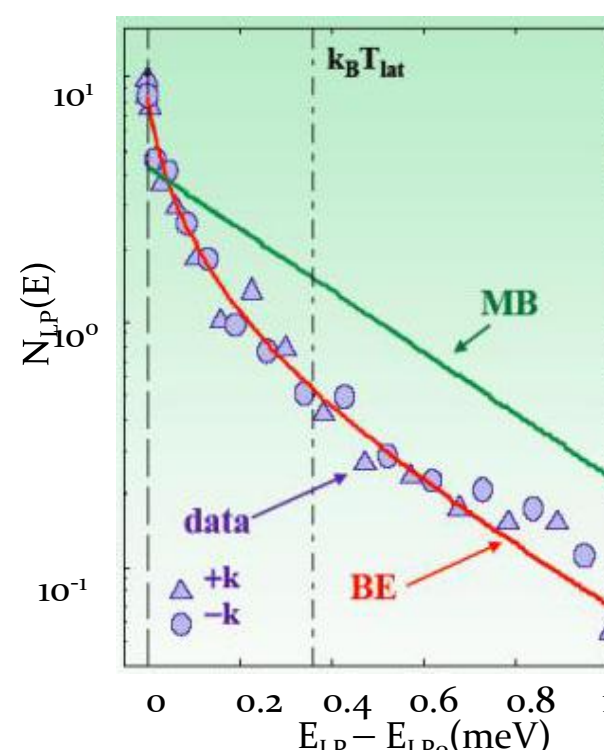


Quantum Degeneracy at Thermal Equilibrium Condition

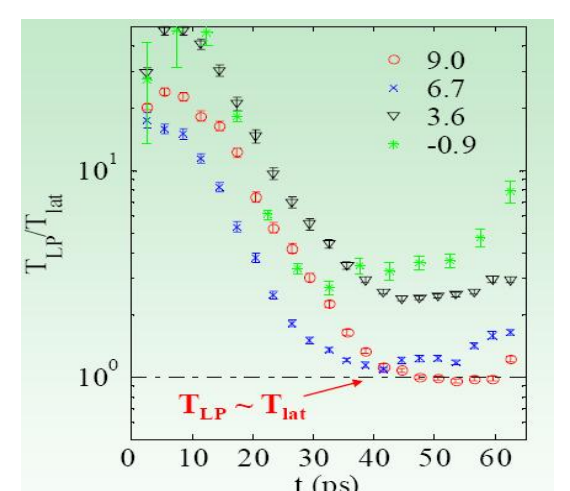
H. Deng et al., Phys. Rev. Lett., 97 146402 (2006)

Temporal BE distribution observed at blue detuning regime ($\Delta = 6.7 \text{ meV}$)

$T_{LP} = 4.4 \text{ K}$, $\mu = -0.04 \text{ meV} < \text{BEC threshold } (-0.35 \text{ meV})$



Time resolved T_{LP} and μ



LP cooled to a lowest T_{LP} @ $t \sim 35 \text{ ps}$
 $T_{LP} \approx T_{LP}$ for $\Delta = 6.7 \text{ meV}$, 9.0 meV

