Mode and Polarization Control in Microcavities

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Polarization of photons plays a key role in quantum optics and light-matter interactions, however, it is difficult to control in nanostructures. Here we demonstrate a polarization control of photons using photonic molecules (PMs) composed of two coupled photonic crystal nanobeam cavities. With an evanescent wave coupling, PMs directly control the local optical field that couples with the emitter, indicating a high efficiency in polarization control. The coupling between PMs is influenced by two primary factors: the air gap d and the relative displacement s between the cavity centers. These two parameters are tuned continuously for high controllability. The supermodes include the symmetric (S) and anti-symmetric (AS) modes are obtained, identified by whether their electric field profiles have the same phase or a π-phase difference. Conventionally, the S and AS mode are linear superpositions of each single cavity and their eigenenergies are $\omega_0 \pm g$ with a symmetric splitting. However, the Hermitian coupling is only valid for a small coupling strength g with a large gap. As the gap d decreases, non-trivial effects arise resulting in an evanescent wave coupling dominated. The evanescent wave enables the control of polarization by introducing a phase shift between the in-plane and out-of-plane electric field at the boundary of dielectrics, which show a significant potential for applications in spin-resolved cavity quantum electrodynamics in future.

<u>Short Bio:</u>

Xiulai Xu received his PhD degree in Cavendish Laboratory in University of Cambridge, United Kingdom. He is currently a professor in School of Physics, Peking University, China. His research is focusing on quantum optoelectronics based on the low dimensional semiconductors.