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Coupling localized spin excitons to an anisotropic nanophotonic vacuum

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Coupling single quantum emitters such as atoms and quantum dots (QDs) to structured photonic reservoir structures is usually assumed to depend on the local density of photon states (LDOS). However, in nanophotonic cavity structures, there is a much richer coupling that can take place - in particular, by controlling the anisotropic vacuum. Photonic crystal waveguides, for example, are periodic semiconductors for light that can control and mold the flow of photons in ways that are not possible in conventional optical structures.

This talk will first introduce the motivation and theory of light-matter interactions and quantum optics control that is possible in slow-light photonic crystal waveguides, with a focus on hybrid QD (artificial atom) photonic-crystal systems. I will discuss the underlying physics of enhanced light-matter interactions and light propagation in these open cavity structures, and give examples where one can controllably emit single photons on a chip and create spin photon entanglers using the remarkable chiral properties of the nanoconfined light fields [1]. I will show why one needs more than just the LDOS to describe light-dipole interactions, and demonstrate a drastic failure of semiclassical theory for light propagation even at the level of a single quantum excitation. Second, I will show how one can exploit anisotropy-induced quantum interference [2] to eliminate single photon spontaneous emission and create population trapping between orthogonal QD exciton states in photonic crystal waveguides and microcavity systems.

[1] A. B. Young, A. Thijssen, D. M. Beggs, P. Androvitsaneas, L. Kuipers, J. G. Rarity, S. Hughes, and R. Oulton, Polarization engineering in photonic crystal waveguides for spin-photon entanglers, Phys. Rev. Lett. 115, 153901 (2015).

[2] S. Hughes and G. S. Agarwal, Anisotropy-induced quantum interference and population trapping between orthogonal quantum dot exciton states in semiconductor cavity systems, Phys. Rev. Lett. 118, 063601 (2017).

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