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Explorations with a new qubit system: Exchange Interactions between Quantum Dot Spin Qubits and Quantum Well Excitons[1]

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In this talk I will present some of our recent work on constructing and optically investigating nanostructures consisting of quantum dots coupled to a nearby quantum well, all embedded in a planar microcavity. The overall goal of this line of work is to develop a platform in which long-range ($\sim$ 1 micron) two-qubit interactions between quantum dots are possible, following the pioneering proposal of Piermarocchi, Chen, Sham, and Steel (*Phys. Rev. Lett.* **89** (16) 167402 [2002]). We have succeeded in demonstrating several fundamental aspects of this platform. We have realized a coupled quantum-dot–quantum-well system in a microcavity, and show that quantum dots in this system can be charged (allowing the storage of a spin qubit), and show that both the quantum dots and the quantum well retain favourable optical properties. Most importantly, we have fairly strong evidence suggesting that the operative mechanism of the theoretical proposals, the spin-dependent exchange interaction between a trapped electron in a quantum dot, and an exciton in the quantum well, is observable, and can be engineered to be of the magnitude required for the implementation of universal quantum gates and measurement operations. I will discuss these results, and highlight other recent (unrelated) work on site-controlled quantum dots, including with quantum dots in positioned nanowires.

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