Hybrid cavity quantum electrodynamics with quantum dot circuits

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In this work, we aim at using the cavity quantum electrodynamics techniques to probe or manipulate the electronic states of quantum dot circuits. In this context, the coherent coupling of a single spin to photons stored in a superconducting resonator is an important milestone. Using a circuit design based on a nanoscale spin-valve, we implement an artificial spin-orbit interaction and coherently hybridize the individual spin and charge states of a double quantum dot made in a single wall carbon nanotube while preserving spin coherence. This scheme allows us to increase by five orders of magnitude the natural (magnetic) spin-photon coupling, up to the MHz range at the single spin level. Our coupling strength yields a cooperativity which reaches 2.3, with a spin coherence time of about 60ns. We thereby demonstrate a mesoscopic device which could be used for non-destructive spin read-out and distant spin coupling.

We have very recently extended such an architecture to Cooper pair splitters which could be used to study spin entanglement in condensed matter. We observe a vacuum Rabi splitting of the photonic mode when brought in resonance with transitions of the Cooper pair splitter. The implications on the coherent Cooper pair injection in such devices will be discussed.