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Long range spin qubit interaction mediated by microcavity polaritons CARLO PIERMAROCCHI, GUILLERMO F. QUINTEIRO, Michigan State University, East Lansing, MI 48824, JOAQUIN FERNANDEZ-ROSSIER, University of Alicante, Alicante, 03690 Spain — Planar microcavities are semiconductor devices that confine the electromagnetic field by means of two parallel semiconductor mirrors. When a quantum well (QW) is placed inside a planar microcavity, the excitons in the QW couple to confined electromagnetic modes. In the strong-coupling regime, excitons and cavity photons give rise to new states, cavity polaritons, which appear in two branches separated by a vacuum Rabi splitting. We study theoretically the dynamics of localized spins in the QW interacting with cavity polaritons. Our calculations consider localized electron spins of shallow neutral donors in GaAs (e.g., Si), but the theory is valid for other impurities and host semiconductors, as well as to charged quantum dots. In the strong-coupling regime, the vacuum Rabi splitting introduces anisotropies in the spin coupling. Moreover, due to their photon-like mass, polaritons provide an extremely long spin coupling range. This suggests the realization of two-qubit all-optical quantum operations within tens of picoseconds with spins localized as far as hundreds of nanometers apart. [G. F. Quinteiro et al., Phys. Rev. Lett. 97 097401, (2006)].

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