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Title

Quantum-dot all-optical logic in a structured vacuum

Source

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Abstract

We demonstrate multiwavelength channel optical logic operations on the Bloch vector of a quantum two-level system in the structured electromagnetic vacuum of a bimodal photonic crystal waveguide. This arises through a bichromatic strong-coupling effect that enables unprecedented control over single quantum-dot (QD) excitation through two beams of ultrashort femtojoule pulses. The second driving pulse (signal) with slightly different frequency and weaker strength than the first (holding) pulse leads to controllable strong modulation of the QD Bloch vector evolution path. This occurs through resonant coupling of the signal pulse with the Mollow sideband transitions created by the holding pulse. The movement of the Mollow sidebands during the passage of the holding pulse leads to an effective chirping in transition frequency seen by the signal. Bloch vector dynamics in the rotating frame of the signal pulse and within the dressed-state basis created by the holding pulse reveals that this chirped coupling between the signal pulse and the Mollow sidebands leads to either augmentation or negation of the final quantum-dot population (after pulse passage) compared to the outcome of the holding pulse alone and depending on the relative frequencies of the pulses. By making use of this extra degree of freedom for ultrafast control of QD excitations, applications in ultrafast all-optical logic AND, OR, and NOT gates are proposed in the presence of significant (0.1) THz nonradiative dephasing and (about 1%) inhomogeneous broadening. (45 References).