Quantum Control of Single-Photon Emission in 2D Materials

The accelerated development of quantum information science is becoming relevant for room temperature quantum technologies. The spin-optical properties of two-dimensional (2D) quantum emitters enable single photons as quantum bits (qubits). In this regard, a negatively charged boron vacancy defect of hexagonal boron nitride (h-BN) such as V_B^- point defect can be made into a room temperature qubit since the large bandgap of h-BN (6 eV) can shield a computational subspace from environmental noise. To design high quality photonic qubits, dynamical simulation that incorporates noise and radiative-like decay is needed to optimize quantum control schemes for h-BN. We develop a Λ-system model of the V_B^- defect Hamiltonian from material properties including key coupling tensors such as zero field splitting, Zeeman effect, and hyperfine splitting. Utilizing an advanced quantum input-output network (QION) theory, we dynamically simulate the temporal states of polarized encoded single photon h-BN and quantum pulse control for single-photon generation on a multi-port master equation. Here we present $g^{(2)}$-correlation increasing with pulse width beyond the non-classical limit ($g^{(2)}(0) > ½$) showcasing the dependency of optimal pulse schemes for polarized single photon qubits in h-BN.

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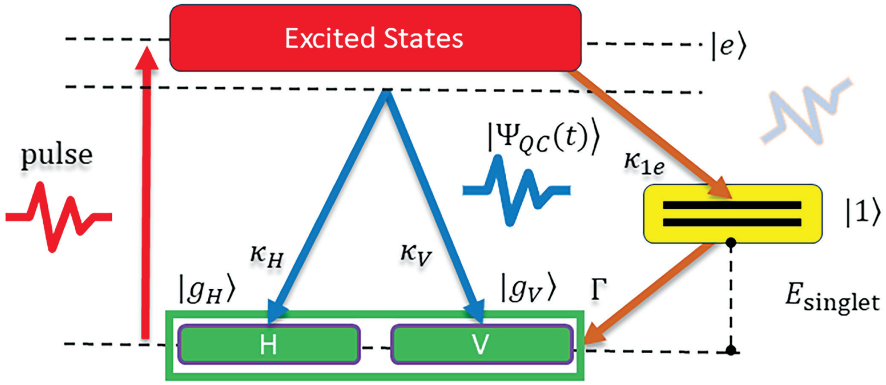
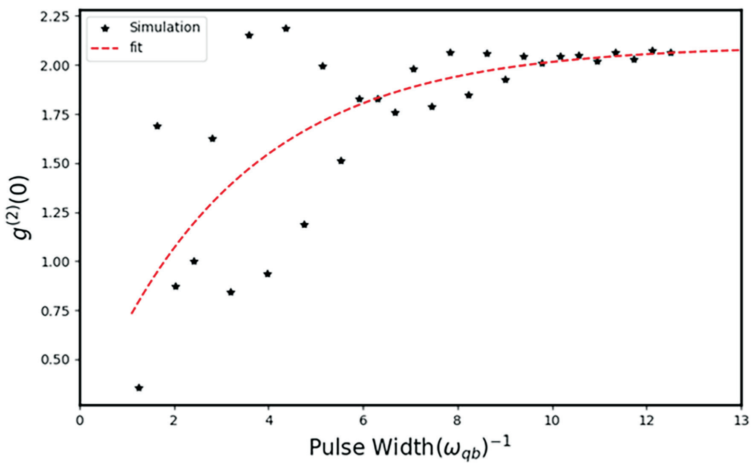
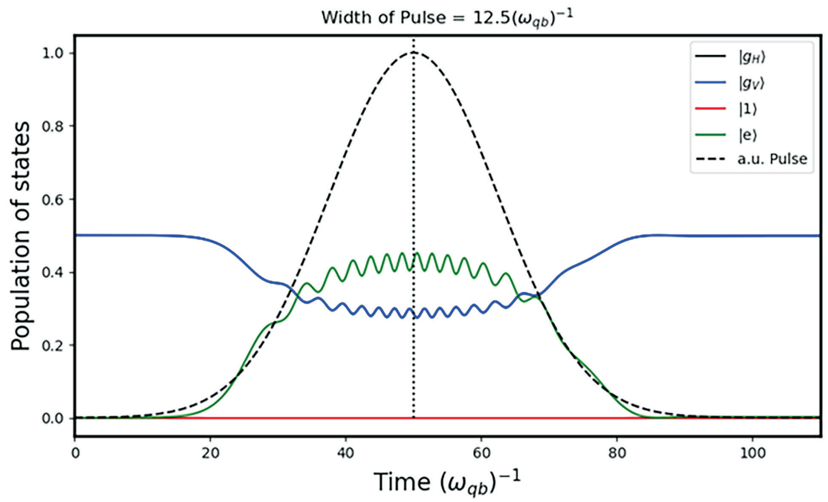


Pulsed Λ-model for polarized-encoded single-photon of hexagonal boron nitride.



$g^{(2)}$-correlation as a function of Gaussian pulse width.



Temporal evolution of h-BN eigenstates from Gaussian pulse.