

Remote Quantum Interference of Quantum Emitters Mediated by Anisotropic Environments

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Abstract:

We have systematically investigated the remote quantum interference engineering in the vicinity of anisotropic environments involving Graphene/hBN Multilayers. Hexagonal boron nitride (hBN) is a natural hyperbolic material, which can also accommodate highly dispersive surface phonon-polariton modes. In a basic scenario, surface plasmons in a monolayer graphene can be coupled with hyperbolic phonon polaritons in a single hBN film to form hybrid polaritons that can assist photon tunneling. In this work, electromagnetic modes calculations in such a hybrid structure obtained beyond retarded approximation based on Green's function techniques, providing exact solutions for all modes complexity. Strong confinement of light in such a device, driven spin-orbit interactions at the nanoscale, allows symmetry breaking and selectively favor one direction by engineering the medium and the dipole spin with a single or multi-emitters. The spectral density of states is immensely enhanced in the vicinity of the graphene-hBN heterostructures, mediating a strong coupling regime and enabling effective quantum interference where the excitation energy can coherently be transferred between the orthogonal quantum-dot exciton states and the subwavelength confinement of optical fields, causing the long-lived entangled exciton states. This can be attributed to an anisotropic quantum vacuum (AQV), which induces quantum interference among radiative decay channels with orthogonal transitions. We are anticipating that hyperbolic material engineering with attainable parameters and accessible experiments holds promise for exploring new paradigms of long-range light-matter interaction for atom optics, solid-state quantum optics, and quantum information processing.