MANY-BODY ELECTRONIC STRUCTURE OF INASP/INP NANOWIRE QDS AND DOT MOLECULES

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InAsP/InP nanowire quantum dots and vertically stacked double-dot structures are promising building blocks for engineered single-photon emitters and coupled level schemes, exploitable in quantum information processing. We present theoretical results using a multiband k·p description for electron and hole states including continuum-elasticity model for strain and evaluation of the associated piezoelectricity, followed by configuration-interaction treatment of the Coulomb-correlated complexes (X0, X±, XX). Radiative recombination rates are evaluated via Fermi's golden rule and results obtained using the dipole approximation (DA) are compared with a beyond-dipole treatment (BDA) implemented in a Poisson-reformulated form compatible with the many-body workflow.

For single InAsP/InP truncated-pyramid dots with sizes and compositions motivated by experimental results, the ground-state exciton transition energy decreases nearly linearly with increasing As content in both zincblende and wurtzite phases allowing tuning the emission energy in the broad spectral range over the telecom windows. Trion and biexciton binding energies vary weakly with composition and show phase-dependent trends. For stacked dot molecules, varying barrier thickness and As content tunes the system from localized to shared states, offering a control of the coupling degree in the associated molecule. Correlated spectra show that configuration mixing shifts transition energies and redistributes oscillator strengths relative to isolated-dot limits.