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Reduced-Density-Matrix Description of Single-Photon and Multi-Photon Processes in Quantized Many-Electron Systems[1] VERNE JACOBS, Naval Research Laboratory, ALEX KUTANA, Rice Universsity — The frequency-dependent transition rates for single-photon and multi-photon processes in quantized many-electron systems are evaluated using a reduced-density-matrix approach. We provide a fundamental quantum-mechanical foundation for systematic spectral simulations. A perturbation expansion of the frequency-domain Liouville-space self-energy operator is introduced for detailed evaluations of the spectral-line shapes. In the diagonal-resolvent (isolated-line) and short-memory-time (Markov) approximations, the lowest-order contributions to the spectral-line widths and shifts associated with environmental electron-photon and electron-phonon interactions are systematically evaluated. Our description is directly applicable to electromagnetic processes in a wide variety of many-electron systems, without premature approximations. In particular, our approach can be applied to investigate quantum optical phenomena involving electrons in both bulk and nanoscale semiconductor materials entirely from first principles, using a single-electron basis set obtained from density functional theory as a starting point for a many-electron description.

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