NONLINEAR INTERSUBBAND DYNAMICS IN SEMICONDUCTOR NANOSTRUCTURES

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ABSTRACT

The intersubband (ISB) dynamics of conduction electrons in semiconductor quantum wells exhibits a variety of interesting and potentially useful nonlinear phenomena. In this work we present three different formalisms which we use to describe ISB effects in the nonlinear regime. We first develop a density-matrix approach based on time-dependent density functional theory (TDDFT) to describe nonlinear ISB conduction electron dynamics in the time domain. We apply this formalism to study coherent control of optical bistability. We then focus on the fact that the exact time-dependent exchange-correlation (xc) potential contains information about the previous history of the system, including its initial state. We describe two different formalisms which go beyond the adiabatic approximation and apply them to collective charge-density oscillations in quantum wells. First, we develop a viscosity-based TDDFT in the time domain and show how the memory and velocity dependence of the viscosity-based xc potential introduces retardation, which in turn leads to decoherence and energy relaxation. The other formalism is the time-dependent optimized effective potential method (TDOEP). We solve the full TDOEP integral equation with exact exchange and show how the memory arises from the exact exchange and results in retardation effects in the electron dynamics.