Electron Interference in a Double-Dopant Potential Structure

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We present an analysis of interference effects as a result of the electron evolution within a coherent transport medium, offering a double-dopant Coulomb potential structure [1]. Injection of coherent electron states into the structure is used to investigate the effects on the current transport behavior within the quantum Wigner phase space picture [2]. Quantum effects are outlined by using classical simulations as a reference frame, a unique feature of Wigner function based transport simulations. In particular, the utilized signed particle approach inherently provides a seamless transition between the classical and quantum domain. Based on this we are able to identify the occurring quantum effects caused by the non-locality of the action of the quantum potential, leading to spatial resonance. Fig. 1 and Fig. 2 show the electron density at 200 fs for all absorbing boundary conditions (i.e. open system) in the classical and in the quantum case, respectively. In the classical case, Fig. 1, no interference pattern materializes beyond the dopants as the action of the force is local. In the quantum case, Fig. 2, the non-locality action of the quantum potential of the dopants affects the injected electrons already right after injection and establishes two transport channels below the dopants. Beyond the dopants (i.e. $y > 30$ nm), interference effects manifest which are highly sensitive to changes of the dopants' potential profiles. Fig. 3 and Fig. 4 compare the cumulative density of the classical and quantum cases at various y positions, clearly depicting the manifesting interference pattern for the quantum case. The results bear a resemblance to the diffraction patterns manifesting over time in double-slit experiments [3,4] and depict the use of dopants to design transport channels as well as specific interference patterns within an open system, all of which are very interesting for novel applications in the area of entangletronics [5].

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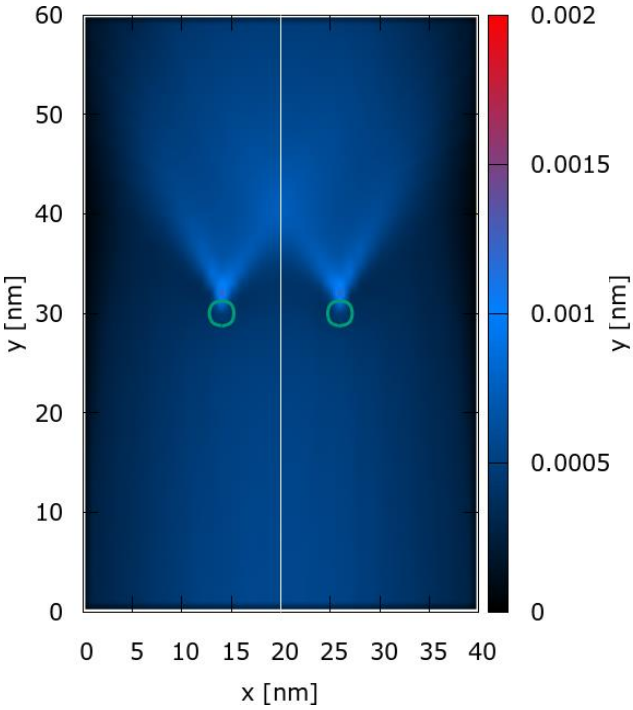

Fig.1: Classical electron density ([a.u.]) after 200 fs of the initial minimum uncertainty condition (absorbing boundary conditions). The green circles are isolines at 0.175 eV of the Coulomb potentials modeling the dopants.

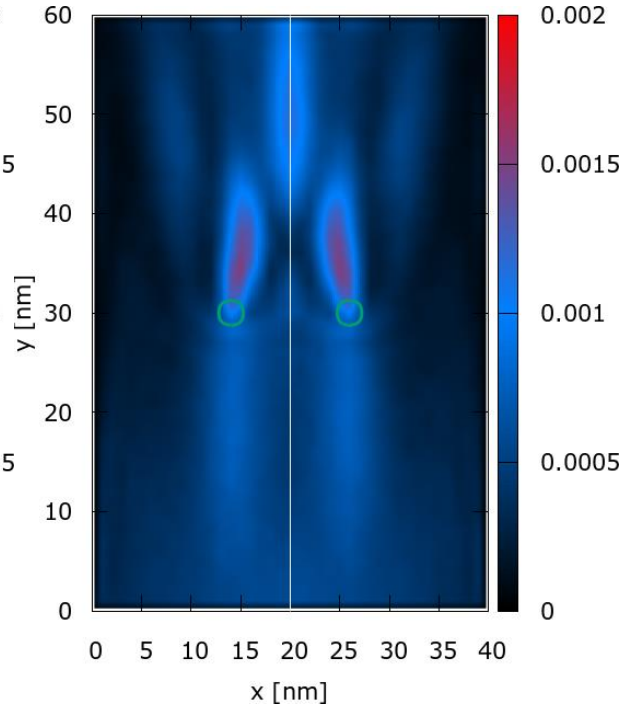

Fig.2: Quantum electron density ([a.u.]) after 200 fs of the initial minimum uncertainty condition (absorbing boundary conditions). The green circles are isolines at 0.175 eV of the Coulomb potentials modeling the dopants.

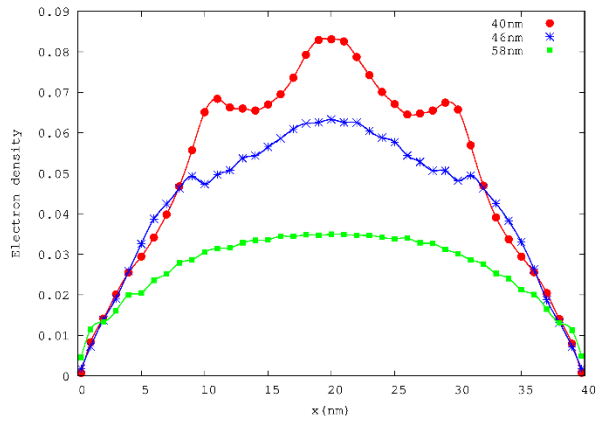

Fig.3: Classical screens show the cumulative density ([a.u.]) recorded at three different y positions.

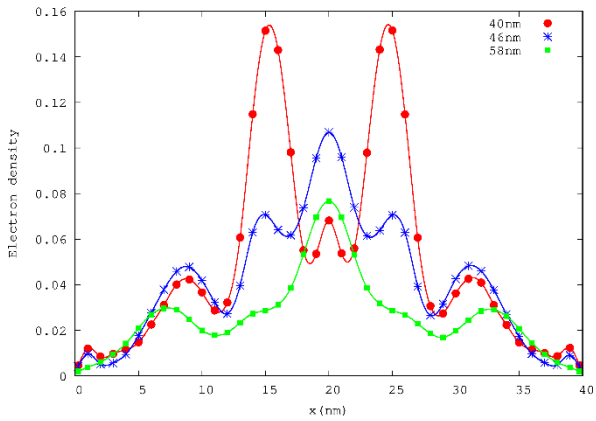

Fig.4: Quantum screens show the cumulative density ([a.u.]) recorded at three different y positions.

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