# Electron Interference and Wigner Function Negativity in Dopant Potential Structures

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We present two experiments in quantum current transport concerning interference effects an the use of Wigner function negativity: (1) We show interference effects as a result of the electron evolution within a coherent transport medium, offering a double-dopant Coulomb potential structure [1]. (2) We discuss the relation between quantum coherence and quantum interference and the negative parts of the Wigner quasi-distribution in a single-dopant Coulomb potential structure [2]. Injections of coherent electron states into the structures are used to investigate the effects on the current transport behavior within the quantum Wigner phase space picture [3,4]. Quantum effects are outlined by using classical simulations as a reference frame, a unique feature of Wigner function based transport simulations. In particular, the 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 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. an 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. The results bear a resemblance to the diffraction patterns manifesting over time in double-slit experiments [5,6] and depict the use of dopants to design transport channels as well as specific interference patterns within an open system. In another experiment, a single repulsive dopant is placed in the transport path of an *open* structure (using absorbing lateral boundary conditions) which creates a quasi-two-slit electron system that separates the wave function into two entangled branches. Here, the negative part of the Wigner function is principally concentrated in the region behind the dopant between the two entangled branches, maintaining the coherence between them (Fig. 3). Moreover, quantum interference is shown in this region both in the negative and in the positive part (Fig. 4). Both experiments are essential steps towards novel applications in the area of entangletronics [1,7].

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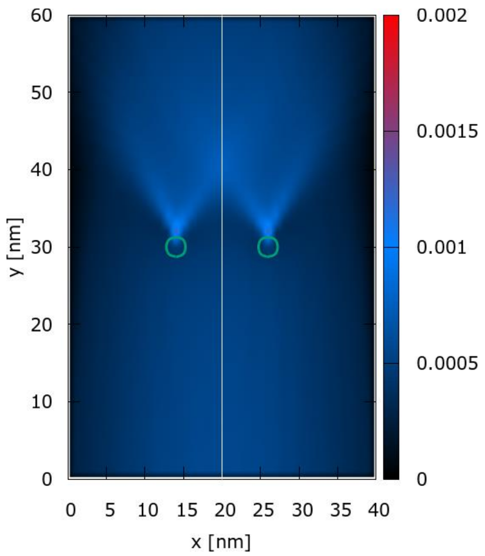

*Fig. 1: Classical electron density ([a.u.]) after 200 fs of the initial minimum uncertainty condition using absorbing boundary conditions (green circles: Coulomb potentials).*

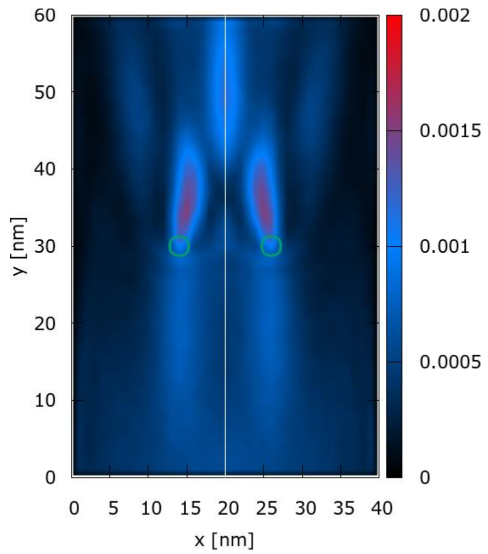

*Fig. 2: Quantum electron density ([a.u.]) after 200 fs of the initial minimum uncertainty condition using absorbing boundary conditions (green circles: Coulomb potentials).*

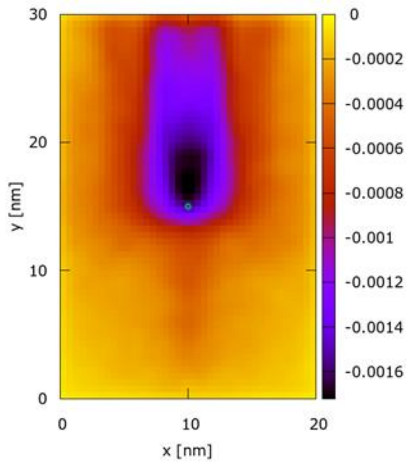

*Fig. 3: Spatial distribution of the negative part of the Wigner distribution.*

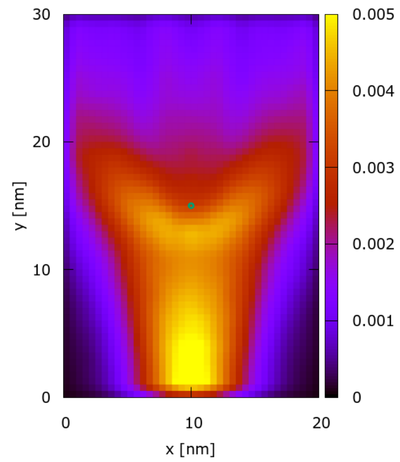

*Fig. 4: Spatial distribution of the positive part of the Wigner distribution.*