Controlling Current and Shot Noise through Molecular Wires

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Recent experimental progress enabled the measurement of weak tunneling currents through molecules which are coupled by sulfur ligands to gold contacts. We investigate the nonlinear current-voltage characteristics and the temperature behavior of inelastic inter-electrode current mediated by a short molecular wire within a kinetic approach that accounts for strong Coulomb repulsion between transferring electrons [1,2]. Upon inclusion of the spin degree of freedom one finds a blocking effect which depends on both the interaction strength and on the wire population [2].

Next, we present a study of the transport properties of such molecular wires under the influence of possibly strong laser irradiation. Our approach is based on the single-particle Floquet states of the driven wire and allows even in the case of large molecules for an efficient numerical treatment beyond linear response. In the absence of certain symmetries, the wire rectifies the laser-induced current resulting in a non-zero average current even if no voltage is applied [3,4] (molecular wire quantum Brownian motors). We find that the current saturates as a function of the wire length such that already a relatively short wire can mimic the behavior of an infinite system. Thus, molecular wires enable to study the behavior of (strictly periodic, thus infinite) coherent quantum ratchets.

As a second class of application, we discuss in presence of a finite, external voltage laser controlled molecular switches and molecular transistors [5]. These laser driven molecular wires give also rise to novel shot noise features [6]. The relative level of transport noise, being characterized by a Fano factor, can selectively be manipulated by ac-sources; particularly one observes characteristic maxima and minima near regimes of driven current suppression.

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