Laser control of electronic currents through single molecules

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During the last years, reproducible measurements of weak tunneling currents flowing through single molecules contacted between metallic leads (molecular wires) have been carried out. As conceivable extension of such experiments, we investigate theoretically the influence of a laser field on the transport properties of the molecular wire. For weak coupling of the molecule to the leads and in the coherent transport regime, we develop a formalism, which permits an efficient calculation of the electrical current flowing through the different molecule-lead contacts.

Within the framework of this formalism, we study two classes of phenomena: The first one is directed transport in the absence of a mean external bias. For a broken (generalised) parity symmetry of the driven molecule, we observe a non-zero time-averaged current, i.e. the molecule acts as a coherent quantum ratchet. The direction of this current depends sensitively both on the driving parameters and on the length of the molecule [1,2]. The second class comprises possibilities of an external control of the electronic transport through the molecule in the presence of an externally applied static voltage. For a two-site molecule connected to two leads, we find for certain driving parameters a strong suppression of the electrical current through the molecule, i.e. a molecular current gate. The reason for this suppression lies in the coherent destruction of tunnelling between the two wire sites. In a three-contact system, the same effect permits the steering of electrical currents by suitably chosen laser fields [3].

[1] J. Lehmann, S. Kohler, P. Hänggi, and A. Nitzan, Phys. Rev. Lett. **88**, 228305 (2002).
[2] J. Lehmann, S. Kohler, P. Hänggi, and A. Nitzan, cond-mat/0208404.
[3] J. Lehmann, S. Camalet, S. Kohler, and P. Hänggi, physics/0205060.