Time dependent current through a quantum dot-ring nanostructure

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Semiconductor quantum structures with typical dimensions between a few nanometers and a few hundred nanometeres are promising candidates for solid state devices of future electronics. Their effective size, shape and electronic properties can often be precisely controlled with the help of electrical gating.

Our study focuses on a structure composed of a semiconductor quantum dot surrounded by a quantum ring (DRN - dot-ring nanostructure). Such a structure has recently been fabricated by the pulse droplet epitaxy [1]. It has been already shown that many properties of the DRN are crucially dependent on the spatial distribution of the electron wave functions [2]. By changing the relative position of bottoms of the quantum dot and quantum ring confining potentials, it is possible to control the strength of the coupling between electronic states in the nanostructure and attached electrodes. This flexibility allows one to use the DRN as a single electron transistor or a current rectifier [3].

In our previous studies we analyzed transport in the steady state. Here, we extend them to take into account the time dependence of the current and occupations of different DRN's electron states. From the point of view of potential applications, it is especially important to know the reaction times when devices like transistors are switched on or off. Using the rate equations we calculate the response to rapid changes of the bias voltage and of the voltage applied to the gate. We demonstrate how the system can be designed to obtain a short response time that would be required in applications based on ac signals.

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[2] E. Zipper, M. Kurpas, M. M. Maśka, *New Journal of Physics* **14**, 093029 (2012).
[3] M. Kurpas, B. Kędzierska, I. Janus-Zygmunt, A. Gorczyca-Goraj, E. Wach, E. Zipper and M. M. Maśka, arXiv:1503.03510.