Application of the dot-ring nanostructure to control electrical transport in the Coulomb blockade regime

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The conducting properties of a two-dimensional nanostructure in the form of a quantum dot surrounded by a quantum ring, named afterwords a dot-ring nanostructure (DRN), are discussed. This complex system is a highly controllable object. It was shown that by changing the confinement potential, e.g., by the electrical gating one can change the shape and distribution of the electron wave functions which determine many physical, measurable quantities. In the recent papers [1] we have shown that one can change the spin relaxation time of the spin memory device by orders of magnitude and the absorption cross section from strong to negligible. Such structures have been recently fabricated [2].

The purpose of this study is to demonstrate a highly controllable transport properties of DRN. Conduction through DRN depends crucially on the coupling strength of its states to the leads, what, in turn, depends on the spatial distribution of the electron's wave functions in DRN. As it was demonstrated in Ref. [1], this distribution can be strongly modified so that the ground and excited states move between the inner dot and the outer ring.

In this paper we show that this property can be used to control single-electron DC current through DRN in the Coulomb blockade regime. We show that one can adjust the confinement potential of DRN so that it can be used as: a) single electron transistor b) electrical current rectifier

The results indicate an opportunity to optimize specific properties of complex nanostructures by means of sophisticated structural design.

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