Application of Picosecond Magnetic Pulses For Inducing An Electron Motion In Bi-Layer Nanowires.

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We consider an interaction of single electron confined in a piece of nanowire with a short magnetic pulse of time duration between a few up to a few tens of picoseconds [1]. If the external confinement of considered nanowire is prepared as a double inverted heterojunction based on e.g. InAs/InGaAs or AlGaAs/GaAs materials and its width in growth direction is quite large (30 nm) then due to unequally doping of the $\delta -$ layers placed below and above the well, two tunnel coupled transport layers are formed inside. For such specific confinement, the vertical components of an electron's wave functions can be easily hybridized in magnetic field. If static magnetic field is directed perpendicularily to both, the wire axis and to the transport layers, such hybridization transforms single minima in the lowest energy subbands E(k) into two deep lateral minima what introduces negative dispersion relation into E(k) and can be experimentally detected in standard conductance measurements [2]. We have found another interesting regime the effect of magnetic hybridization in the bi-layer nanowire can be used for, namely, to change the electron's motion energy in short period of time [3]. This results directly from the Faraday law $\partial\vec{B}/\partial t = -\nabla \times \vec{E}$ which predicts the formation of temporary electric field with opposite directions in both the upper and lower layers when the magnetic pulse pierces the nanostructre. Based on the results of computer simulations we have found that for a symmetric confinement in vertical (growth) direction, both parts of a single electron wavepacket move in nanowire in opposite directions according to local electric field. However, if the confinement is nonsymmetric, the majority of the electron density is accelerated into arbitrarily chosen direction dragging simultaneously the minority against the local electric field in second layer what results in a coherent motion of both parts of an electron wavepacket. In our work we present a simple theoretical model taking into account the magnetic hybridization effect and show how its magnitude depends on three factors: i) the degree of the confinement asymmetry, ii) efective mass of an electron and, iii) the time duration of the magnetic pulse. We also show how this new effect combined with the Coulomb Blockade mechanism can be utilized as a buliding block of the magnetically driven current valve.

[1] C. Vicario, C. Ruchert, F. Ardana-Lamas, P. M. Derlet, B. Tudu, C. P. Hauri, *Nat. Photon.* **7**, 720 (2013).
[2] T. Chwiej, *Physica E* **77**, 169 (2016).
[3] T. Chwiej, *arXiv:1601.03880* (2016).