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Mesoscopic Physics, Quantum Transport, Spintronics, Valleytronics

Our group focuses on the exploration of physics in novel nanostructures and the possible applications of these physics. Quantum transport is the key property of our interest, and with that we have addressed issues on graphene and related systems, edge-state physics, all-electric valley-polarized current generations, all-electric spin-pumping, and all-electric spin-accumulation. Our findings in the above issues are highlighted with examples in the following. **[1] Nodal physics in graphene nanoribbon**: We have found that nodal sites in armchair graphene nanoribbons (AGNR) offer new possibilities. Adsorbate located on such a site forms a bound state (Fig. 1(a)), shows Fano characteristics in conductance (Fig. 1(b)), and provides adsorbate recognition, even in the presence of disorder. **[2] Gate-generated edge-states in graphene**: We find that edge-states can be generated by electrical means (Fig.2). The fact that it does not require a threshold gate-voltage is remarkable. We expect it to have a topological origin, and is in the process of finding it out. **[3] All-electric generation of valley-polarized current**: We have shown that a time-modulated gate acting upon a collimated beam in graphene can have valley-filtering properties (Fig. 3) via coherent inelastic processes. **[4] Valley polarization via a slanted graphene junction**: We show that a slanted AGNR connected to a graphene sheet results in valley-resolved beam splitting (Fig. 4). There are conditions when one of the valley-resolved beam disappears. **[5] Spin pumping**: We have shown that a single time-modulated gate is sufficient to generate spin pumping (Fig. 5 (a), (b)). **[6] Spin accumulation**: A nonuniform driving electric field is shown to be the key for spin accumulation generation in semiconductors (Fig. 6).

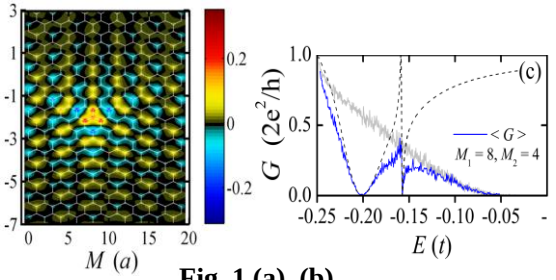


Fig. 1 (a), (b)

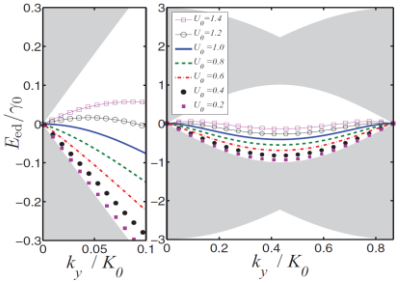


Fig. 2

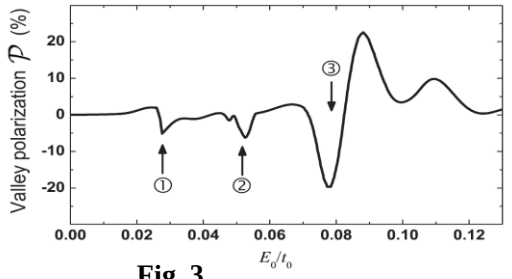


Fig. 3

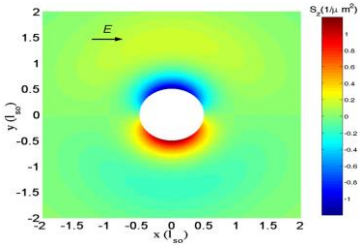


Fig. 6

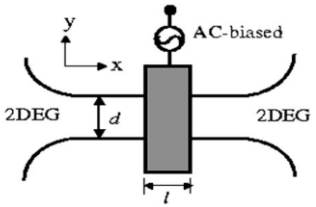
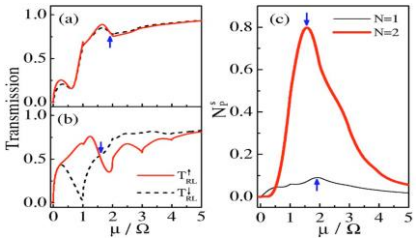


Fig. 5 (a), (b)



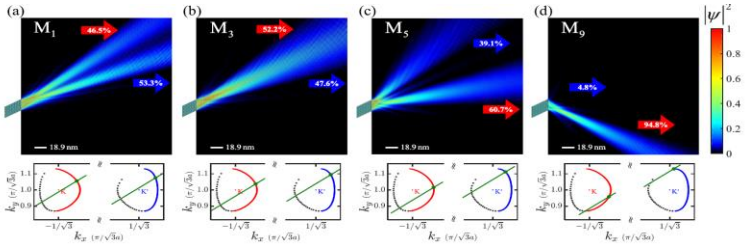


Fig. 4