Spin-polarized quantum pumping in zigzag graphene nanoribbons

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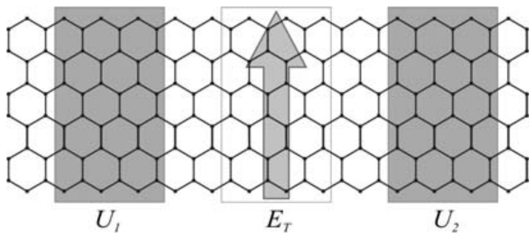
The experimental discovery of graphene in 2004 has initiated intense experimental and theoretical research of this material [1]. Due to its attractive properties, such as electric field controlled conductivity, long spin lifetimes, large spin diffusion lengths and two-dimensional nature, graphene is considered as a good candidate for applications in electronics and spintronics.

Infinite graphene is non-magentic, but some of its derivative nanostructures, such as nanoislands, nanoribbons and defective graphene sheets, demonstrate magnetism. Specifically, zigzag nanoribbons are predicted to have antiferromagnetic structure at low doping with up-spins and down-spins being localized at opposite edges of a ribbon [2]. This fact paves the way for generating spin-polarized currents in graphene by breaking the symmetry between the edges [3].

We use a simple tight-binding approximation and a constant magnetization model [3] to numerically demonstrate that the quantum pump effect [4] in zigzag nanoribbons can be used to generate spin currents and pure spin currents (finite spin current with vanishing total electric current) provided the symmetry between up-spins and down-spins is broken. We propose two such mechanisms: a defect localized at one of the edges and a transverse electric field.

The considered effect may be utilized in graphene based spintronics devices as a method of controlled generation of spin-polarized currents.



Schematic of a zigzag nanoribbon based quantum pump device. Pumping is achieved by a cyclic variation of gate voltages U_1 and U_2. The symmetry between up-spins and down-spins is broken by a transverse electric field E_T (or by a defect – not shown).

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