Spin filtering from asymmetric strain and electron-electron interaction in zigzag graphene ribbons

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We explore the combined effect of strain and electron repulsion intensity in zigzag graphene nanoribbons. The calculations are based on tight-binding and Hubbard models and take into account the system temperature and chemical potential. We demonstrate that, on top of the induced energy gap around the charge neutrality point, strain significantly modifies the energy bands. Opposite compressive and tensile strain along the direction of the ribbon section induces a spin-splitting of the low-energy band. This is an alternative mechanism compared to other existing proposals for inducing spin-splitting in zigzag graphene nanoribbons based on defect engineering [1], transverse electric field effect [2] and nonuniform strain engineering [3,4]. By means of transport simulations based on the non-equilibrium Green's function formalism self-consistently coupled with the Poisson equation, we show the possible application of this phenomenon in a spin-valve device.

References

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[2] J. Guo et al., Applied Physics Letters, 92 (2008) 163109
[3] F. Ildarabadi et al., Physical Review B, 103 (2021) 115424
[4] H.-K. Ke et al., Results in Physics, 56 (2024) 107206

Figures

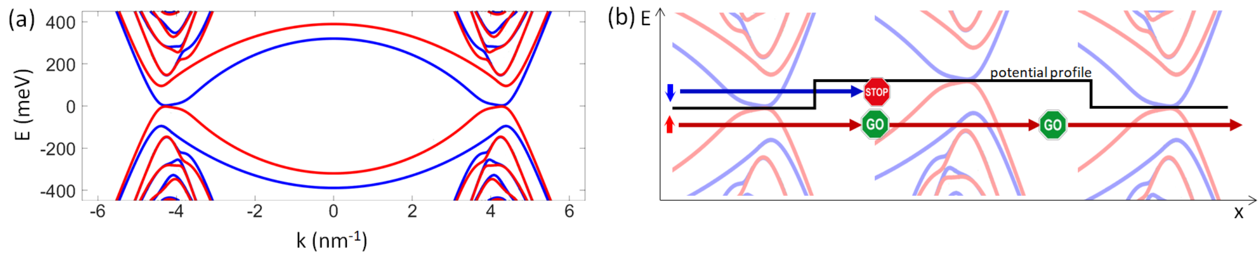

Figure 1: (a) Energy bands of a 20 nm-wide zigzag graphene ribbon with 5% compressive and tensile strain on the edges over a width of 5 nm. Red (blue) lines refer to spin up (down) electrons. The spin splitting of the lowest-energy bands can be exploited for spin-valve devices simulated in our work and whose mechanism is sketched (b).

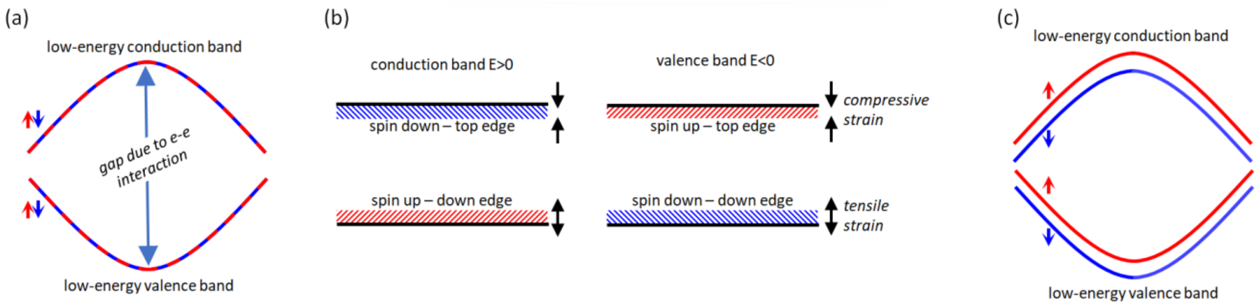

Figure 2: Mechanism at the origin of the spin-splitting. (a)Low-energy bands in the absence of strain. (b) Corresponding spatial distribution of electrons with up and down across the zigzag graphene ribbon. (c) Spin-splitting in the presence of asymmetric strain on the ribbon edges, as indicated in (b).