Crossed graphene nanoribbons for electron quantum optics and spintronics

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Graphene nanoribbons (GNRs) are emerging as versatile platforms for quantum technology, leveraging tunable electronic and π-magnetic properties [1]. The minimal spin-orbit and hyperfine interactions inherent in graphene position GNRs as prime candidates for developing sophisticated functionalities, including spin filters, spin qubits, and electron quantum optics setups.

In our theoretical exploration, we examine electronic transport within devices composed of crossed zigzag GNRs, applying the mean-field Hubbard model alongside Green's function techniques under open boundary conditions. By orienting one ribbon across another at approximately a 60º angle, we find that electron waves, upon injection from an electrode, are split at the junction into two of the three outgoing ports. Importantly, with edge spin polarization taken into account, our findings suggest that such arrangements can serve as efficient spin-polarizing beam splitters [2]. We extend our study to Mach-Zehnder-like interferometers utilizing zigzag GNR arrays to study quantum interfererence [3], underpinning the versatility and potential of GNRs in constructing complex quantum devices.

References

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Figures

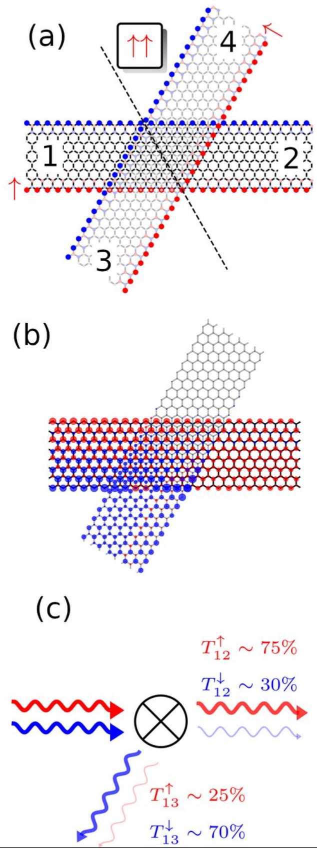

Figure 1: A spin-polarizing beam splitter with two crossed GNRs [2]. **(a)** Spin density configuration in a device composed of two AB-stacked 8-ZGNRs. **(b)** Spin-resolved scattering state of electrons incoming from the left in the conduction band (E-E_F=0.5 eV). **(c)** Sketch of incoming/outgoing waves at the intersection with the corresponding spin-resolved transmission probabilities indicated.