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Magnetism in Graphene Pseudospin

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Commentary

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COMMENTARY

Since its discovery, graphene has become a magnetic device with its unique magnetic properties (weak spin-orbit coupling, longer spin coherence, giant magneto-resistance, and longer spin relaxation time), which make it become the perfect preparation material for spin electronic devices. On the opposite hand, two-dimensional Hexagonal Boron Nitride (h-BN) crystals with an equivalent lattice structure as graphene but different in electronic properties. With its unique magnetic properties (semi-metallic magnetic, spin selective, spin transport), which make its potential applications in terms of spin electronics and other applications. Especially the graphene/h-BN heterostructure, the performance is clearly different from the superb magnetic and spin electron properties (no attenuation of the transmission characteristics, magnetic tunneling resonance, etc.), making the graphene/h-BN heterostructure becomes ideal since spin electronic materials.

Spin to pseudo-spin conversion by which the non-equilibrium normal sublattice pseudo-spin polarization might be achieved by magnetic flux has been proposed in graphene. Calculations are performed within the Kubo approach for both pure and disordered graphene including vertex corrections of impurities. Results indicate that the traditional magnetic flux produces pseudo-spin polarization in graphene no matter whether the contribution of vertex corrections has been taken under consideration or not. This is often due to non-vanishing correlation between the and provided by the co-existence of extrinsic Rashba and intrinsic spin-orbit interactions which mixes normal spin and pseudo-spin. For the case of pure graphene, valley-symmetric spin to pseudo-spin response function is obtained. Meanwhile, by taking under consideration the vertex corrections of impurities the obtained response function is weakened by several orders of magnitude with non-identical contributions of various valleys. This valley-asymmetry originates from the inversion symmetry breaking generated by the scattering matrix. Finally, spin to pseudo-spin conversion in graphene might be realized as a practical technique for both generation and manipulation of normal sublattice pseudo-spin polarization by an accessible magnetic flux during an easy way. This novel proposed effect not only offers the chance to selective manipulation of carrier densities on different sublattice but also might be employed in data transfer technology. The traditional pseudo-spin polarization which manifests itself as electron population imbalance of various sublattices are often detected by optical spectroscopy measurements.

Spin and pseudospin properties of monolayer graphene, when both the exchange and extrinsic Spin-Orbit (SO) interactions are taken under consideration, are analyzed within a framework of geometric algebra. The rotor equations for even and odd parts of electron bispinor are constructed in three-dimensional (3D) Euclidean space thus providing clear geometrical interpretation to the matter. It is shown that within the presence of combined action of exchange then interactions the spin and pseudospin fields during a monolayer graphene from two-dimensional become 3D, with spin and pseudospin components remarking of the graphene plane. Also, the effect of both interactions on the Berry phase is taken into account analytically.

The ability to control pseudospin can find applications in Dirac-material based spintronics. Unlike the transport of real spin which will be modulated by a magnetic flux, some sort of magnetization, or a spin-transfer torque, pseudospin doesn't answer a magnetic flux, making modulating pseudospin transport a challenging task. We articulate an asymmetrically coupled cavity-waveguide configuration in graphene and uncover a phenomenon: making the classical dynamics of the cavity deformed can effectively modulate and enhance pseudospin polarization within the waveguide. The underlying mechanism of this remarkable phenomenon is often attributed to chaos-assisted tunneling, which has been well documented in nonrelativistic quantum systems but not yet in Dirac material systems. The finding establishes the feasibility to develop pseudospin modulators for graphene systems through externally applied electrical potential only, with fidelity over 10% at the effective distance of several cavity sizes along the waveguide..