Quantum and Spin transport in strained graphene: Concepts and Experimental Perspectives

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Abstract

Strain in graphene can be harnessed to generate effective gauge fields that dramatically impact its electronic and spin transport properties. These gauge fields include scalar potentials shifting the Dirac point energy[1], and vector potentials suppressing the ballistic transport[2]. When the effective gauge fields exhibit a non-zero curl, large pseudo-magnetic fields—exceeding 300 T in graphene nanobubbles [3]—can emerge, leading to the formation of pseudo-Landau levels observed via ARPES on patterned substrates [4]. Also, graphene with low spin–orbit coupling and weak hyperfine interactions exhibits long spin diffusion lengths and high spin lifetimes on flexible substrate [5]. In this research, we investigate how such strain-induced gauge fields influence spin transport in graphene. We present the fabrication of strained graphene devices and the experimental design for spin transport measurements, with the goal of understanding how mechanical deformations can modulate spin relaxation and diffusion.
Furthermore, we plan to study the interplay between spin and valley degree of freedom in strained graphene. By introducing well-defined strain profiles, we aim to probe how valley-dependent gauge fields might influence spin transport. These insights advance the potential of strain engineering in spintronic applications based on two-dimensional materials and may open pathways toward its integration with spin-based quantum technologies.

References

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