Casimir Physics Surprises in the Graphene Family

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Dirac material have become an interesting playground not only for discoveries of novel properties and effects, but also for investigating various types of interactions. The Casimir force is a universal interaction originating from electromagnetic fluctuations between objects, however, its magnitude, sign, scaling laws, and other dependences are strongly affected by the interacting systems and their extensions [1]. 2D Dirac materials, such as graphene, silicene, germanene, and stanene, offer new opportunities to re-evaluate the Casimir force functionalities and its control. These systems are representatives of the graphene class of materials and here I will present an overview of their atomic structure, energy bands, and optical response properties. The graphene family exhibits various topological phase transitions under external fields, which largely become possible due to the significant spin orbit coupling and finite staggering in silicene, germanene, and stanene (Fig. 1). Based on the Kubo formalism and low energy Hamiltonian, we compute the optical conductivity tensor for the entire phase diagram by taking into account the frequency and wave vector dependences, which are then used to describe a rich structure of the response in this family of materials [2]. The phase transitions, captured in the electronic and optical properties, strongly impact their Casimir interactions, in which novel distance scaling laws, magnitude and sign changes, and force quantizations become possible [3]. The complex interplay between Dirac physics, spin orbit coupling, and external factors in the studied 2D systems strongly suggest that materials beyond standard metals and dielectrics hold promise for fundamental discoveries in fluctuation induced interactions.

References

