Monolayer graphene nanoflakes in electric and magnetic field

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One of the manifestations of interplay between charge and spin degrees of freedom in solid state systems is the influence of electric and magnetic fields on both the electrical and magnetic properties. From the point of view of the developing spintronics, highly interesting phenomena involve, for example, the manipulation of the magnetic properties and interactions (particularly in the nanoobjects) with the electric field. Such a possibility concerns also graphene and its nanostructures, which constitute promising spintronic platforms [1,2].

Usually, the present studies separate the influence of magnetic field (e.g. [3]) and of electric field (e.g. [4]) on the magnetic properties of graphene nanostructures. Therefore, it appears particularly interesting to characterize the simultaneous influence of both fields on the graphene nanostructure magnetism, what is the subject of the present work [5].

The main aim of the paper is to discuss the z component of the total spin of selected monolayer graphene nanoflakes (quantum dots) in their ground state as a function of the external electric and magnetic field [5]. Both fields are oriented in the plane of the nanoflake. Two classes of nanostructures are studied: triangular nanoflakes with armchair edge and short sections of armchair nanoribbons with zigzag terminations; neither of them shows magnetic ordering in the absence of external fields. The stability ranges of magnetically unordered phase and ferromagnetic orderings with various total spin value are found, what leads to the construction of a considerably rich magnetic phase diagram. Within the phase with total spin equal to zero, some ranges of antiferromagnetic orderings are identified. In addition to the studies of the charge-neutral nanoflakes, the influence of charge doping with a single charge carrier on the phase diagram is illustrated and the cases of electron and hole doping are contrasted. The total ground-state energy of the charge carriers in nanostructures is investigated in parallel with the behaviour of particular single-particle energy states in external fields. The results yield the picture characteristic of either continuous or discontinuous phase transitions. Finally, the process of magnetization of the nanoflake in increasing magnetic field is studied and the influence of the electric field on it is characterized.

The computational support on Hugo cluster at Laboratory of Theoretical Aspects of Quantum Magnetism and Statistical Physics, P. J. Šafárik University in Košice is gratefully acknowledged.

This work has been supported by Polish Ministry of Science and Higher Education on a special purpose grant to fund the research and development activities and tasks associated with them, serving the development of young scientists and doctoral students.

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