Magnetic field induced vortices in graphene quantum dots

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Abstract

The current densities distribution induced by a magnetic field in semi-conductor quantum dots was studied by Slachmuylders et al in 2005[1]. There, vortex patters were observed, in resemblance to vortices in mesoscopic superconductors. In this work, we investigate the current densities pattern induced by a perpendicular external magnetic field on eigenstates of three types of graphene quantum dot (QD). Eingenstates are obtained by numerical diagonalization of the tight-binding Hamiltonian. We consider graphene quantum dots with square and triangular geometries with zig-zag or armchair edges. We observe that the energy spectrum of these quantum dots in the presence of an external magnetic field are similar to that of circular dots, but with crossings replaced by anti-crossing, see Fig.1. We analyze how the geometries and sizes influence this result. Then, we find the distribution of local current densities in the presence of an applied magnetic field, for each geometry mentioned above. Finally, we verify that if there are vortex states for these current densitiesm showing in Fig.2, and investigate how they relate to angular momentum states, in analogy to what we have for the case of semiconductor quantum dots.

References

[1] A. Slachmuylders et al, Phys. Rev. B 71, 245405 (2005).

Figures

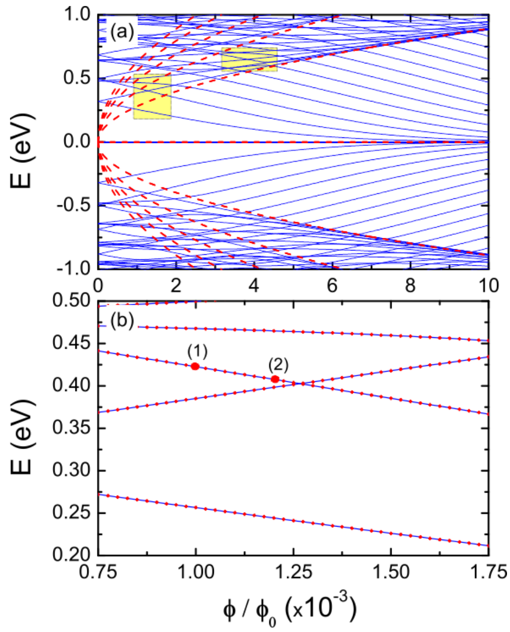

Figure 1: (a) Energy spectrum of a triangular zigzag graphene quantum dot (TZZGQD) with 50 carbon rings in each of its sides, as a function of the magnetic flux through a single carbon hexagon, where $\phi_0 = h/e$ is the quanta of magnetic flux and the red lines are the Landau's levels. (b) Sectors of this energy spectrum emphasizing crossings.

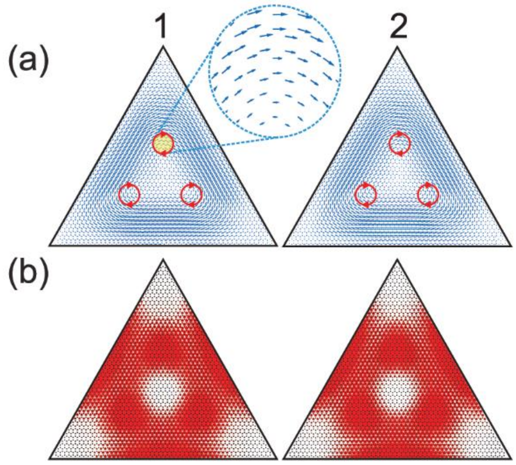

Figure 2: Vortices in a TZZGQD (a) and probability density electronics (b) corresponding to the energies of (1) and (2) of Fig. 1(b).