Energy levels of quantum rings in bilayer graphene

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We propose a novel system where electron and hole states are electrostatically confined into a quantum ring in bilayer graphene. This proposal is based on the fact that in bilayer graphene a gap in the electronic spectrum can be created and modified by means of a gate voltage [1].

Since in our proposed structure the bilayer graphene sheet is assumed to be defect-free and the confinement is brought about by an external bias the disadvantages of the edges do not arise in our system. In addition the ring parameters can be tuned by external fields. Our results display interesting new behaviors in the presence of a perpendicular magnetic field *B*, which have no analogue either in semiconductor-based or in lithography-based graphene quantum rings [2,3], such as an overlap between magnetically confined Landau levels (in which the carriers are mainly located in the center of the ring) and electrostatically confined states.

In particular, the eigenvalues are not invariant under a $B \rightarrow -B$ transformation and, for a fixed total angular momentum index *m*, their field dependence is not parabolic, but displays two minima separated by a saddle point. The spectra also display several anti-crossings, which arise due to the overlap of gate-confined and magnetically-confined states. The existence of Aharonov-Bohm oscillations for both electrons and holes are still linked with flux quantization through the ring. This novel spectra obtained for a finite width quantum ring [4] can be understood by means of a toy model for an ideal zero width ring in which case analytical results can be obtained [5].

References

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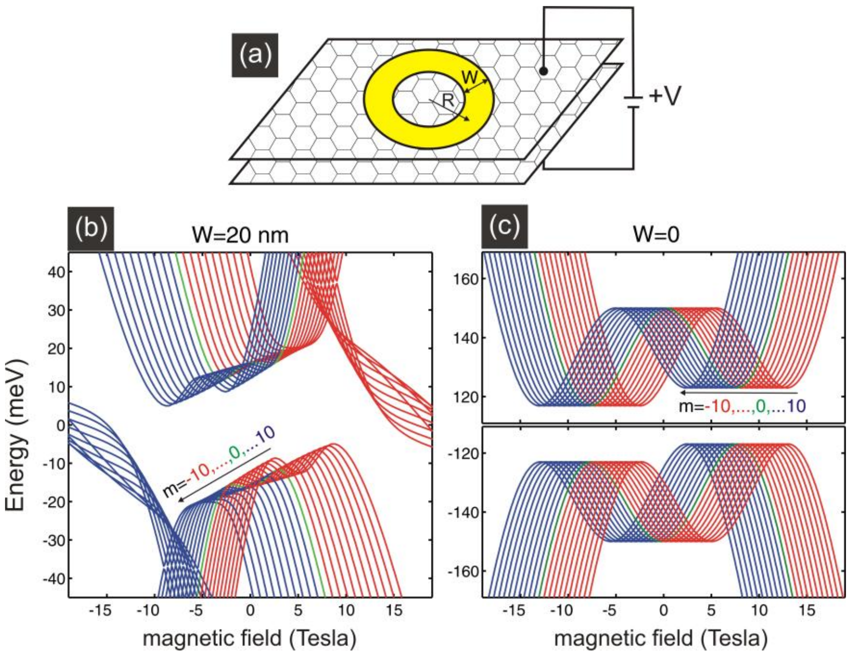
Figures



(a) Schematic depiction of a electrostatically confined quantum ring in bilayer graphene. Panels (b) and (c) show electron and hole states as function of external magnetic filed with gated voltage V=150 meV and ring radius R=50 nm respectively for the ring width W=20 nm and zero width. In panel (c) the energy levels are obtained analytically. The energy levels are shown for the quantum numbers |m|≤10.