Two-point Green's function correlations mediated by localized electronic edge modes in zigzag graphene nanoribbons

Arash Akbari-Sharbaf* and Michael G. Cottam[&]

*Département de Physique, Université de Sherbrooke, Québec, Canada J1K 2R1
(email: arash.akbari.sharbaf@usherbrooke.ca)
[&]Department of Physics and Astronomy, University of Western Ontario, Ontario, Canada N6A 3K7

The unusual nature of the localized electronic edge modes in zigzag graphene nanoribbons (ZZ-GNRs) have been the subject of intense investigation since its inception above 20 years ago by Fujita *et al*. [1]. Nearly all theoretical investigations related to edge modes in ZZ-GNRs have been carried out numerically or semi-numerically. Here we will present the first comprehensive analytical investigation of the localized edge modes in ZZ-GNRs demonstrating that two possible distinct type of localized modes with strikingly different properties can exist in the system [2]. The first type of localized edge mode (or "zero" mode) is a topologically induced mode arising from the bipartite honeycomb lattice structure of graphene and is always present at zigzag edges. The second type of edge mode is only present at zigzag edges with a modified hopping parameter between edges sites distinct from the hopping between interior sites. In particular we demonstrate that correlations mediated by the zero mode between two atomic sites on the same edge is comparable to correlations between two atomic sites on opposite edges and independent of the width of the ribbon in leading order and in the absence of zero-mode damping effects. We also demonstrate the strength of correlations are strongly dependent on the sublattice labels of any two atomic points being considered. On the other hand correlations mediated by the "modified hopping" edge mode is independent of the sublattice labels and the two edges decouple when the width of the ribbon is greater than the attenuation length of the modified edge mode. Analytical expressions and numerical results are presented for the dependence of the mode frequencies on the ribbon width and on wave number parallel to the ZZ edges.

[1] M. Fujita, K. Wakabayashi, K. Nakada, and K. Kusakabe, J. Phys. Soc. Jpn **65** (1996) 1920.
[2] A. Akbari-Sharbaf and M. G. Cottam, Phys. Rev. B **93** (2016) 235136.