DEPARTAMENTO DE FÍSICA FUNDAMENTAL

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Majorana Zero Modes in Graphene

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A clear demonstration of topological superconductivity (TS) and Majorana zero modes remains one of the major pending goals in the field of topological materials. One common strategy to generate TS is through the coupling of an s-wave superconductor to a helical half-metallic system. Numerous proposals for the latter have been put forward in the literature, most of them based on semiconductors or topological insulators with strong spin-orbit coupling. Here, we demonstrate an alternative approach for the creation of TS in graphene-superconductor junctions without the need for spin-orbit coupling. Our prediction stems from the helicity of graphene's zero-Landau-level edge states in the presence of interactions and from the possibility, experimentally demonstrated, of tuning their magnetic properties with in-plane magnetic fields. We show how canted antiferromagnetic ordering in the graphene bulk close to neutrality induces TS along the junction and gives rise to isolated, topologically protected Majorana bound states at either end. We also discuss possible strategies to detect their presence in graphene Josephson junctions through Fraunhofer pattern anomalies and Andreev spectroscopy. The latter, in particular, exhibits strong unambiguous signatures of the presence of the Majorana states in the form of universal zero-bias anomalies. Remarkable progress has recently been reported in the fabrication of the proposed type of junctions, which offers a promising outlook for Majorana physics in graphene systems.

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