Purcell enhancement by the edge states of zig-zag graphene nanoflakes

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Graphene nanoflakes with zig-zag edges exhibit distinct and highly localized edge states [1,2] that impart metallic character to the edges, while the interior remains insulating. This pronounced spatial variation in electronic behaviour makes such systems particularly attractive for nanophotonic applications. When a quantum emitter is placed near the flake[3], coupling to these edge states can significantly enhance its spontaneous emission rate, whereas the insulating bulk contributes minimally. These edge states are geometric rather than topological in origin, rendering them sensitive to external perturbations. In this work, we analyse the behaviour of these states across various nanoflake geometries like triangular, hexagonal, and rhombic focusing on their stability under electron-electron interactions and doping. We find that in the absence of interactions, coupling to edge states consistently enhances the emitter's decay rate. However, the persistence of these edge-induced transitions depends strongly on sublattice symmetry [4]: sublattice balanced geometries support edge states even under weak interactions, while sublattice-imbalanced structures lose them rapidly. Interestingly, we demonstrate that careful doping can partially restore edge-state transitions in sublattice-imbalanced flakes, offering a pathway to engineer and control light-matter interactions in graphene nanostructures through both geometry and electronic tuning.

References

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Figures

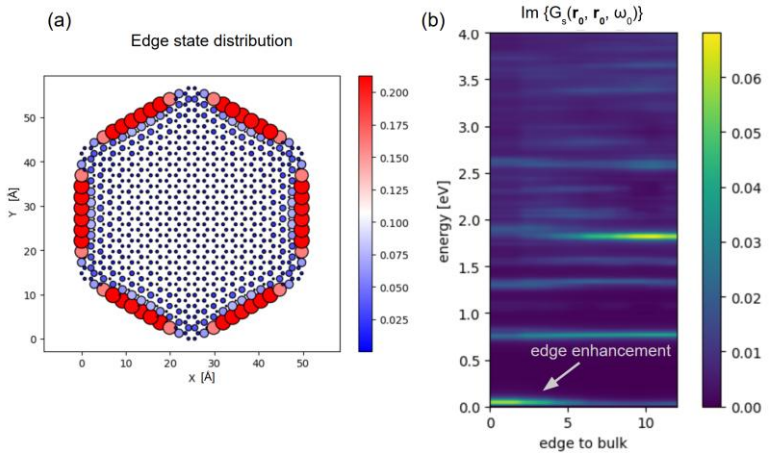

Figure 1: (a) Geometric edge states of a hexagonal zigzag graphene flake. (b) Imaginary part of scattered Green's function as a function of the position of the quantum emitter from edge to bulk.