# Electronic band engineering using bonding-antibonding pairs in topological domain walls

**Ricardo Y. Díaz-Bonifaz**
Carlos Ramírez Ramos
*Departamento de Física, Facultad de Ciencias, Universidad Nacional Autónoma de México, Ciudad de México 04510, México*
rdiazbnfz2015@ciencias.unam.mx

Topological matter exhibits unique phenomena with enormous applicability such as the appearance of robust edge states that decay exponentially into the bulk and cannot be destroyed by adiabatic perturbations. Distinct topological phases are identified by topological invariants that do not change continuously. In these terms, topological domains are formed when the value of an invariant changes within different parts of a system, resulting in the creation of topological domain walls (TDWs) in the interface within two adjacent non-equivalent domains [1]. The edge states that appear in TDWs present themselves as an opportunity to exploit topologically protected localization far from the physical borders of the material. For instance, recent works have shown the existence of currents that travel exclusively through topologically protected states along TDWs with arbitrary forms even when additional bulk states are present [2].

To further explore the possibilities offered by TDWs in electron transport it is crucial to consider that edge states from two adjacent domains are close enough to interact, which might modify their energy spectrum. In this work we address this issue by modelling infinite graphene nanoribbons in the quantum Hall regime with a TDW parallel to the physical borders of the system. The TDW is produced by a non-uniform magnetic field which is introduced into a tight-binding Hamiltonian following the graphic algorithm described in Ref. [3]. The one-dimensional band structure of these nanoribbons reveals that the edge states along the TDW form bonding-antibonding pairs. We characterize these pairs by calculating their eigenfunctions, inverse-participation ratio (IPR) and their normalized distance from the TDW. Moreover, we show that the band deformations caused by the edge state pairs can be controlled by modifying the applied magnetic field to increase the TDW width. Thus, the edge states along the TDW can be spectrally isolated from their counterparts in the physical borders of the system in a tunable way by means of external fields.

**Acknowledgements:** This work was supported by UNAM-PAPIIT IN116025. Ricardo Y. Diaz-Bonifaz thanks SECIHTI for the graduate scholarship granted. Computations were performed at Miztli under project LANCAD-UNAMDGTIC-329.

References

[1] K. Yasuda, et. al., Science 358 (2017) 1311
[2] S. Yin, et. al., Science Bulletin 69, (2024) 1660
[3] R. Y. Díaz-Bonifaz and C. Ramírez, J. Phys.: Condens. Matter 37 (2025) 105301