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Square lattice toy models for topological analysis

The study of electronic, optical and magnetic properties involves Schrödinger and Heisenberg many body equations. Even for nanoscopic systems find solutions to theses system equations is a formidable task. In Chemistry, Linear Combination of Atomic Orbitals was developed for molecular systems studies. Using a heuristic approach to LCAO called Tight Binding, was developed in Physics to obtain initial insights for solid state matter properties. This approach involves a minimum computational infrastructure.

In this pedagogical work, we analyze a square lattice toy model using tight binding approach to observe the evolution of eigenvalues and eigenstates of the system when we applied different interacctions such as intrinsic and Rashba Spin Orbit Coupling, the competition between them; and, the effect of magnetic and electric fields over the eigenvalues and eigenstates. We analyze the edge states of the system, the Berry phase and quantify the Chern number associated to conductivity. Also, we present the results of a deep learning analysis of these toys models, an initial results are shown.

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