Resilient Intraparticle Entanglement and its Manifestation in Spin Dynamics of Disordered Dirac Materials [1]

Jorge Martínez Romeral
Aron W. Cummings and Stephan Roche
ICN2, Bellaterra (Barcelona), Spain.
jorge.martinez@icn2.cat

Topological quantum matter exhibits novel transport phenomena driven by entanglement between internal degrees of freedom, as for instance generated by spin-orbit coupling effects [2]. Here we report on a direct connection between the mechanism driving spin relaxation and the intertwined dynamics between spin and sublattice degrees of freedom in disordered graphene, Figure 1. Beyond having a direct observable consequence, such intraparticle entanglement is shown to be resilient to disorder, pointing towards a novel resource for quantum information processing, Figure 2.

References

[1] Jorge Martínez Romeral, Aron W.Cummings, Stephan Rochei: arXiv:2310.17950 (2023)
[2] Bruna Gabrielly de Moraes, Aron W.Cummings, Stephan Roche, Phys Rev B, 102 (2020) ,041403.

Figures

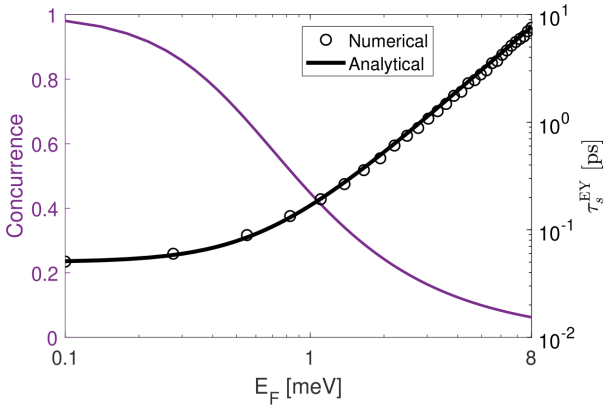

Figure 1: Numerical and analytical spin relaxation times due to the EY mechanism (black, right axis), along with the concurrence (purple, left axis), as a function of the Fermi energy.

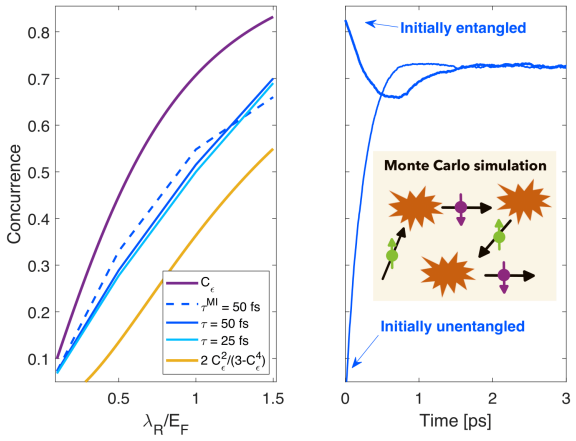

Figure 2: Left panel: Concurrence for different scattering times in the presence of charge impurities (solid line) and magnetic impurities (dashed line). The solid purple line indicates the concurrence of the eigenstates of the system and the upper bound of the converged concurrence,and the solid yellow line represents the lower bound Right panel: concurrence dynamics for the initial states. The inset shows a schematic of the semiclassical Monte Carlo simulation.