Resilient intraparticle entanglement in graphene

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Excitations with high entanglement between spin and pseudospin have been previously reported in graphene [1]. However, it remains an open question how this intraparticle entanglement behaves under random scattering induced by impurities. In this work, we demonstrate that entanglement remains resilient under different types of scattering, including momentum, spin, and intervalley scattering. We also show that the value to which the entanglement converges does not depend on the initial state, as shown in Figure 1. On the other hand, previous studies have suggested a link between this type of entanglement and spin dynamics [2], we further demonstrate this relation with the spin relaxation time, as shown in Figure 2. Additionally, we apply our methodology to AB stacked graphene, which has a controllable band gap via doping or gating [3], allowing us to control the emerging entanglement.

References

[1] Bruna Gabrielly de Moraes, Aron W. Cummings, Stephan Roche, Phys Rev B, 102 (2020) ,041403.
[2] Tuan, Dinh Van and Ortmann, Frank and Soriano, David and Valenzuela, Sergio O. and Roche, Stephan, Nat Phys, 10 (2014) 857—863.
[3] McCann, Edward and Koshino, Mikito, Rep Prog Phys, 76 (2013), 056503.

Figures

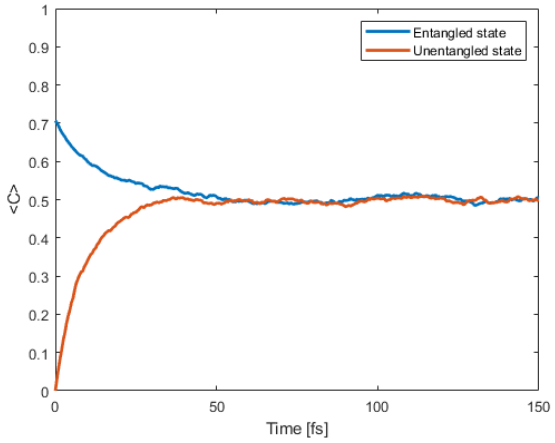

Figure 1: Evolution of concurrence of an initially entangled and unentangled state for a momentum relaxation time of 5 fs, a Rashba spin-orbit coupling of 100 μeV and a Fermi energy of 100 μeV under random momentum scattering.

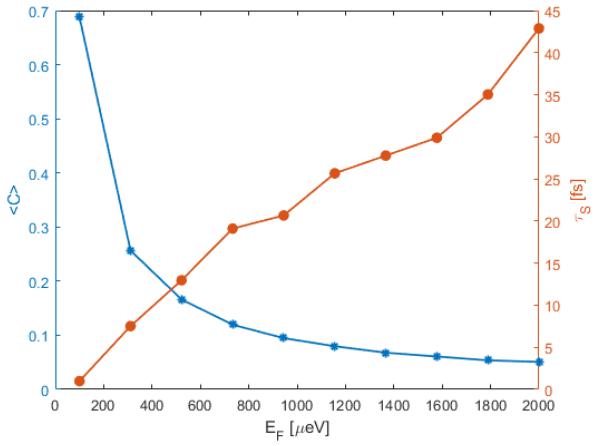

Figure 2: Converged concurrence and spin relaxation time depending on the Fermi energy for a Rashba spin-orbit coupling of 150 μeV and a momentum relaxation time of 5 fs.