Intraparticle entanglement in graphene

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We demonstrate the emergence and dynamics of intra-particle entanglement in massless Dirac fermions. This entanglement, generated by spin-orbit coupling, arises between the spin and sublattice pseudospin of electrons in graphene. The entanglement is a complex dynamic quantity but is generally large, independent of the initial state. Its time dependence implies a dynamical violation of a Bell inequality, while its magnitude indicates that large intra-particle entanglement is a general feature of graphene on a substrate. These features are also expected to impact entanglement between pairs of particles, and may be detectable in experiments that combine Cooper pair splitting with nonlocal measurements of spin-spin correlation in mesoscopic devices based on Dirac materials.

References

[1] BG de Moraes, AW Cummings, and S Roche, *PRB* **102**, 041403(R) (2020)

Figures

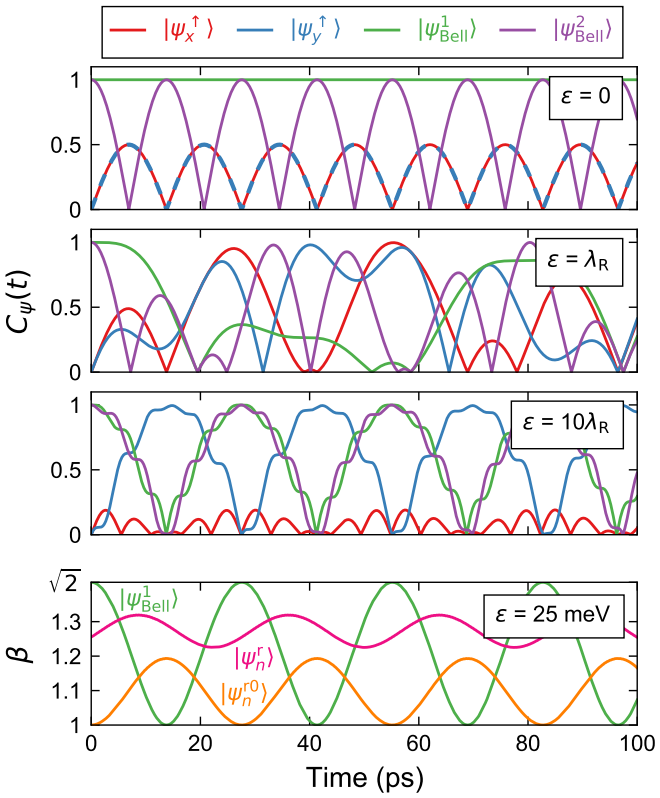

Figure 1: Entanglement dynamics of a few states at different energies. The top three panels show the concurrence of some specially-chosen states. The bottom panel shows the degree of Bell inequality violation for one Bell state and two randomly chosen states.
Image taken from Ref. [1].

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