Optimal Charge-to-Spin Conversion Tuned by Intraparticle Entanglement

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Charge-to-spin conversion lies at the heart of next-generation spintronic devices, where spin-orbit coupling (SOC) efficiently generates a current-driven spin polarization to control a magnetic state. Van der Waals materials present a unique platform for the development of such devices as their electron, spin and optical properties can be enriched by proximity effects [1]. In this context, graphene emerges as a promising spintronic platform, as SOC is activated by proximity with a transition metal dichalcogenide (TMD) [2]. This allows to generate a current-driven spin polarisation via the Spin Hall and Rashba-Edelstein effects in a graphene/TMD bilayer, as well as long distance spin transport in an isolated graphene layer [3]. Understanding the role of intraparticle entanglement between spin and sublattice degrees of freedom remains a challenge in this topic. These effects have been proposed to be detrimental for spin diffusion [4] and spin-momentum locking [5]. Here, we understand intraparticle entanglement as a limiting factor for charge-to-spin conversion in graphene, which we minimize by adequately tuning SOC. By these means, we achieve charge-to-spin conversion with *maximal efficiency* throughout a wide spectral range. We additionally show that intraparticle entanglement enables novel charge-to-spin conversion mechanisms in spin-orbit torque devices [6].

References

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Figures

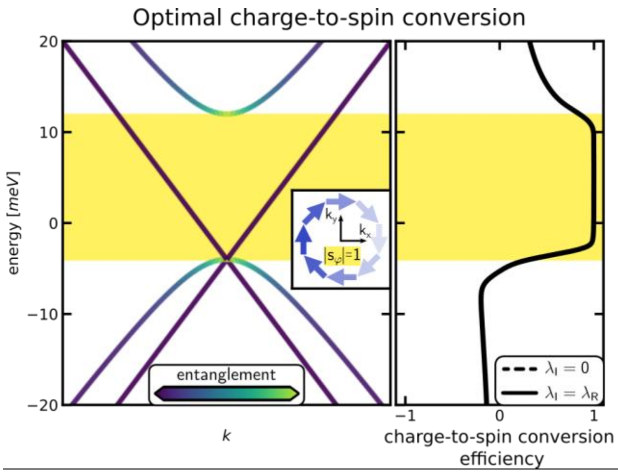

Figure 1. Charge-to-spin conversion with maximal efficiency is obtained across the entire Rashba pseudogap, highlited in yellow, where only a single spin-helical band with no intraparticle entanglement crosses the Fermi level