Charge-to-Spin Conversion in Graphene Proximitized by 1T-TaS_2

Maedeh Rassekh[1, a)], Marko Milivojevic[2, 3, b)], and Martin Gmitra[1, 4, c)]

[1]*Institute of Physics, Pavol Jozef Šafárik University in Košice, Park Angelinum 9, 04001 Košice, Slovakia*
[2]*Institute of Informatics, Slovak Academy of Sciences, 84507 Bratislava, Slovakia*
[3]*Faculty of Physics, University of Belgrade, 11001 Belgrade, Serbia*
[4]*Institute of Experimental Physics, Slovak Academy of Sciences, 04001 Košice, Slovakia*.

[a)] Corresponding author: maedeh.rassekh@upjs.sk
[b)] marko.milivojevic@savba.sk
[c)] martin.gmitra@upjs.sk

Abstract. An essential part of the development of spintronic devices is the generation of spin current through charge-spin interconversion. It has been shown that proximity of a transition-metal dichalcogenide to graphene can significantly affect its magnetism and spin texture. Specifically, the spin-orbit coupling induced by the TMDC complements graphene's high-quality charge and spin transport. Among the most promising materials for charge-to-spin conversion research is 1T-TaS_2, which includes both strong spin-orbit coupling and spontaneous formation of charge density wave (CDW) phase at low temperatures. Placing graphene on top of 1T-TaS_2 results in the proximity induced spin-orbit coupling that depends on CDW phase. Here, using an effective tight-binding model combined with quantum transport calculations, we investigate the production of spin-polarized currents by the flow of an unpolarized current across a single layer of graphene proximitized with 1T-TaS_2. We demonstrated an overall spin accumulation for the perpendicular spin component to the plane. Notably, the sign of the accumulated spin density depends on the nature of the injected current, either electron or hole. Furthermore, injecting electrons with spins in the longitudinal direction results in a spin separation perpendicular to the current direction, which indicates the occurrence of the spin Hall effect. Interestingly, these results remain consistent, regardless of the normal or CDW phases. Our findings provide new insights into the fundamental behavior of spin currents in graphene-TaS_2 heterostructures, underscoring the potential of these materials for advancing spintronic devices.