Anisotropic spin dynamics in proximitized graphene

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While electronics exploits the charge degree of freedom of electrons, spintronics benefits from their spin to process and store information. Graphene stands out as a medium for spin transport due to its carbon-based composition, which ensures very low spin-orbit coupling (SOC) and allows spins to propagate over very long distances. However, weak SOC limits spin manipulation.

Two-dimensional (2D) layered materials, integrated into vertical van der Waals heterostructures, offer unique opportunities for engineering novel physical properties through proximity-induced phenomena [1]. In this work, we investigate spin dynamics in hybrid graphene–transition metal dichalcogenide (TMDC) systems, where proximity-induced SOC is introduced into graphene by adjacent high-SOC TMDCs. Graphene/TMDC spin devices with spin-sensitive contacts were fabricated to study spin dynamics in pristine graphene (as a reference) and in graphene partially covered by a TMDC crystal.

Prior studies have reported strong spin lifetime anisotropy in graphene with the hierarchy $\tau_z >> \tau_x; \tau_y$ and isotropic in-plane spin lifetimes $\tau_x = \tau_y$ for highly symmetric TMDCs such as WSe_2, WS_2, MoS_2 and $MoSe_2$ [2]. We demonstrate that low-symmetry TMDCs, such as pentagonal $PdSe_2$ [3], further modify this hierarchy, yielding in-plane spin lifetime anisotropy ($\tau_{x'} \neq \tau_{y'}$ where x' and y' are orthogonal directions in the graphene plane, with x' defined as the direction of maximum spin lifetime). Our experiments also reveal a directional dependence of the spin lifetimes across all spatial directions, underscoring the richness and versatility of proximity-induced phenomena in these hybrid systems [4].

References

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Figures

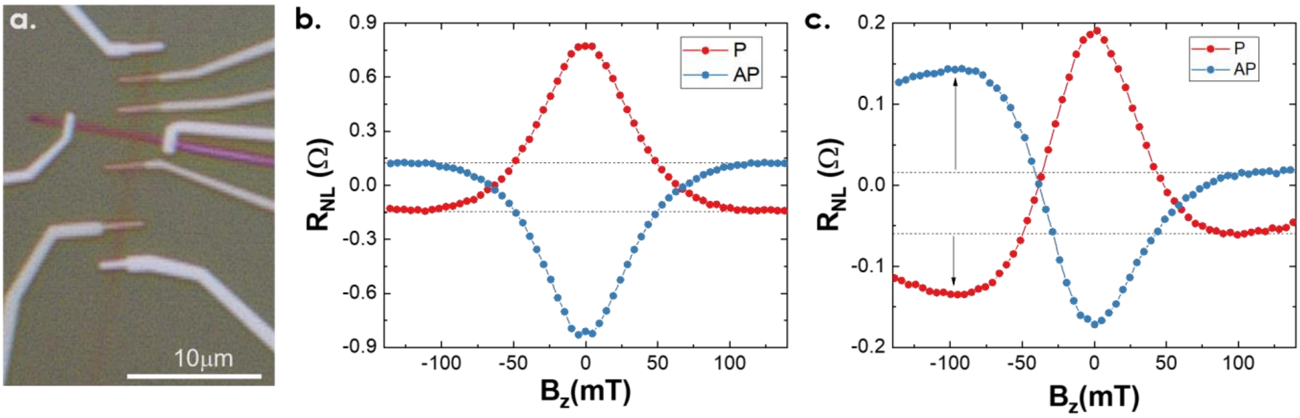

Figure 1: a. Graphene/TMDC spin valve. **b**. Parallel and antiparallel spin Hanle precession curves in bare graphene. **c**. Parallel and antiparallel Hanle spin precession curves in graphene showing in-plane anisotropy.