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# Tailoring Spin Dynamics through Proximity Effects in Graphene/Transition Metal Dichalcogenide Heterostructures

Since its discovery, graphene has been a promising material for spintronics: its low spin-orbit coupling, negligible hyperfine interaction, and high electron mobility are obvious advantages for transporting spin information over long distances. However, such outstanding transport properties also limit the capability to engineer active spintronics, where strong spin-orbit coupling is crucial for creating and manipulating spin currents. To this end, transition metal dichalcogenides, which present larger spin-orbit coupling and good interface matching with graphene, appear to be highly complementary materials for enhancing the spin-dependent features of graphene while maintaining its superior charge transport properties. In this work, we present a recently developed theoretical framework used to understand the current experimental measurements. Specifically, we will concentrate on the effect of valley-Zeeman and inter-valley scattering in weak anti-localization, spin lifetime anisotropy and spin Hall Effect, providing a comprehensive theoretical description of the interconnection between these phenomena. We will also discuss on the possibilities of Graphene/TMDCs heterostructures as a spin-orbit torque platform.

## References

[1] Jose H. Garcia , Aron W. Cummings and Stephan Roche. Nano Lett., 8(2017) 5078.
[2] Aron W. Cummings, Jose H. Garcia, Jaroslav Fabian, and Stephan Roche. Phys. Rev. Lett., 119(2017) 206601.
[3] Talieh S. Ghiasi, Josep Ingla-Aynés, Alexey A. Kaverzin, Bart J. van Wees. arXiv:1708.04067 (2017).
[4] L. A. Benítez, J. F. Sierra, W. Savero Torres, A. Arrighi, F. Bonell, M. V. Costache, S. O. Valenzuela. arXiv:1710.11568 (2017)

## Figures

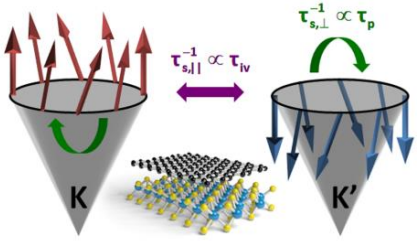


**Figure 1:** Schematic of spin relaxation in graphene-TMDC heterostructures. The tall arrows depict the effective spin-orbit field within the Dirac cones at K and K0 valleys. Intervalley scattering dominates the in-plane spin dynamics, while overall momentum scattering controls the out-of-plane behavior.

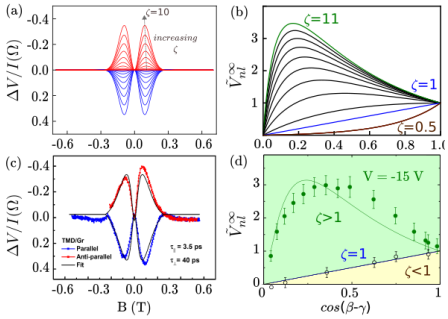


**Figure 2:** (a) Theoretical non-local resistance for in-plane magnetic field for different values of anisotropy ranging for 1 to 10. (b) Normalize asymptotic non-local voltage as a function of an oblique magnetic field, for different values of anisotropies. (c) Experimental values of the non-local resistance modulated by an in-plane magnetic field obtained from ref. [3]. Normalized asymptotic non-local voltage as a function of the oblique angle for pristine graphene and Gr/WS$_2$ obtained from ref. [4].