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Intrinsic limitations of spin transport in 2D membranes[1]

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Two dimensional membranes have become the playground for both theorists and experimentalists due to their unique intrinsic properties emerged from simple lattice structures. They are the new focus of spintronic applications. Therefore, it is important that we have a clear view of the relaxation processes in spin transport, limited by their intrinsic and symmetry structures. In this talk, we present our findings [1,2] by systematically applying group theory to the coupling of phonons and transport carriers in spin-dependent scattering. Scattering by phonon is amplified in 2D membranes due to its unique and populous flexural mode. Opposite spin coupling by one flexural phonon is allowed by symmetry, unlike the momentum scattering by higher-order two flexural phonons. Furthermore, we specifically discuss the ultrafast electron spin relaxation in single-layer transition metal dichalcogenides (SL-TMDs) [1]. The additional factor stems from the decoupling of tiny conduction band spin splitting and the large spin scattering constant. The former results from conduction band orbital orientation, while the latter comes from inter-band coupling and reflects the atomic SOC strength. We will present that the essential use of group theory (invariant quantities) elucidates various spin-dependent selection rules of electron/hole-phonon interaction, within and between all relevant band-valley edges. Multiple potential applications of the derived results can be explored in transport problems, such as the strain effects [2], spin Gunn effect, hot exciton dynamics [1], and the scattering angle and spin anisotropy dependence. We compare different 2D membranes (graphene, SL-TMD, silicene and germanene) from general consideration of the lattice and band-edge symmetries.

[1] Y. Song and H. Dery, Phys. Rev. Lett., 111, 026601 (2013).
[2] T. Cheiwchanchamnangij, W. Lambrecht, Y. Song and H. Dery, Phys. Rev. B, 88, 155404 (2013).

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