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Spin Hall effect in heavy metals: mechanisms and optimization

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The discovery of new spin-to-charge conversion effects (spin Hall effect (SHE), Rashba-Edelstein effect, spin-momentum locking) is expanding the potential of applications such as the magnetization switching of ferromagnetic elements for memories [1] or the recent proposal of a spin-orbit logic [2] which can have a strong technological impact. Finding routes to maximize the SHE is not possible as long as it remains unclear which is the dominant mechanism in a material. I will present a systematic study in Pt, the prototypical SHE material, using the spin absorption method in lateral spin valve devices. We find a single intrinsic spin Hall conductivity in a wide range of conductivities, in good agreement with theory. By tuning the conductivity, we observe for the first time the crossover between the moderately dirty and the superclean scaling regimes of the SHE, equivalent to that obtained for the anomalous Hall effect. Our results explain the dispersion of values in the literature and find a route to maximize this important effect [3]. We also studied the mechanisms in Ta, a material with a claimed giant SHE. Finally, I will show how to optimize the spin-to-charge current conversion at room temperature by combining Pt with a graphene channel [4], opening up exciting opportunities towards the implementation of spin-orbit-based logic circuits.

[1] C. K. Safeer et al., Nat. Nanotech. 11, 143 (2016)
[2] S. Manipatruni et al., arXiv:1512.05428
[3] E. Sagasta et al., Phys. Rev. B 94, 060412(R) (2016)
[4] W. Yan et al., arXiv:1702.01971 (accepted in Nature Comms.)

Primary author(s) : Prof. CASANOVA, Felix (CIC nanoGUNE)

Presenter(s) : Prof. CASANOVA, Felix (CIC nanoGUNE)

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