Spin-Relaxation Phenomena in Graphen: Proximity-Induced Spin-Orbit Coupling Yields Novel Type of Ultrafast Spin Relaxation

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Abstract

Spin transport and spin relaxation are intriguing and strongly debated phenomena in graphene, first, because of unexpectedly short spin diffusion times despite vanishingly small intrinsic spin-orbit interaction and hyperfine coupling, but also because of controversially debated spin relaxation mechanisms.

On the other hand, proximity induced spin-orbit coupling can trigger interesting phenomena in graphene such as the quantum spin Hall effect [1], which can be realized by single ad-atom deposition [2]. Similarly, the intercalation of Au atoms between graphene and a Ni(111) surface has been shown to create giant spin-orbit splitting at the Dirac point reaching 100 meV [3] even for dilute cases, thus demonstrating the efficiency of such proximity effects.

We explore the effect of spin-orbit interaction induced by dilute ad-atom deposition on graphene by means of an efficient time-propagation approach. We monitor the spin-dynamics of initially polarized states that propagate in graphene under presence of such impurities and extract spin precession times and spin-relaxation times. From a comparison to the momentum scattering time we infer different relaxation mechanisms which can only partially be described with established Dyakonov-Perel and Elliot-Yafet mechanisms. We analyze various crossovers as a function of Fermi-level position and momentum scattering time which can be tuned by the disorder potential.

We will also comment on the influence of the direction of the initial spin polarization.

References

[1] C. L. Kane and E. J. Mele, Phys. Rev. Lett. **95**, 226801 (2005).
[2] C. Weeks, J. Hu, J. Alicea, M. Franz, and R. Wu, Phys. Rev. X **1**, 021001 (2011)
[3] D. Marchenko, A. Varykhalov, M. R. Scholz, G. Bihlmayer, E. I. Rashba, A. Rybkin, A. M. Shikin, and O. Rader, Nature Comm. **3**, 1232 (2012)
[4] D. V. Tuan, F. Ortmann, D. Soriano, and S. Roche (submitted)

Figures

(a) **(b)**

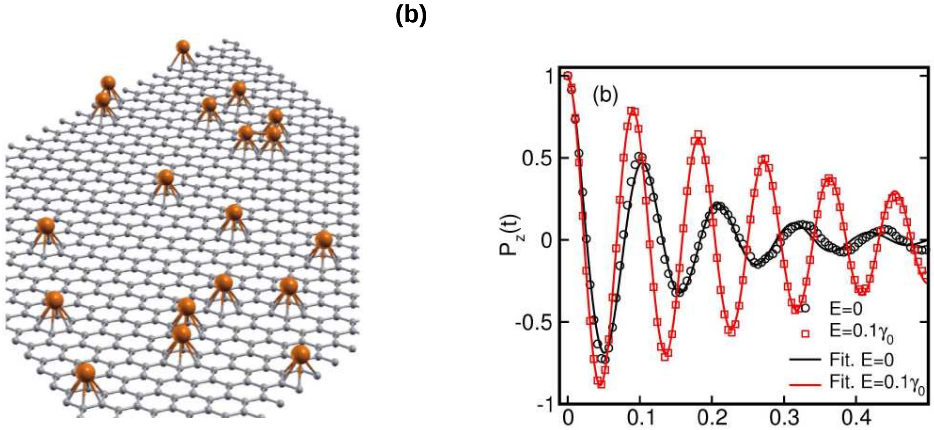

Fig. 1 (a) Graphene with ad-atom impurities adsorbed on hollow sides that induce an effective spin-orbit interaction. (b) Spin-polarization dynamics over time for out-of-plane spin injection. Spin decay depends on the Fermi energy.