Nonlinear electric generation of magnetization in time-reversal-even centrosymmetric metals

Guang-Yu Guo,[1,2,*]

[1] *Department of Physics, National Taiwan University, Taipei 10617, Taiwan;*
[2]*Physics Division, National Center for Theoretical Sciences, Taipei 10617, Taiwan*

Electric field generation of transverse spin current and spin-polarization in nonmagnetic materials are two central topics in all-electric spintronics. In contrast to spin current that can be driven by spin Hall effect in all systems, the electric field (current) induced spin polarization is limited to noncentrosymmetric metals (known as spin Edelstein effect). On the other hand, nonlinear responses of solids have been attracting increasing interest. This is because they dominate in materials where linear responses are symmetry-forbidden, probe quantum geometric quantities and provide novel methods to control materials. In particular, DC electric field induced nonlinear anomalous Hall effect in noncentrosymmetric crystals are connected with Berry curvature dipole and quantum metric dipole, while optical field induced nonlinear photocurrent currents are manifestations of Hermitian connection and Riemannian curvature. In this talk, I will present our recent proposal of a time-reversal-even spin generation in centrosymmetric solids in second order of electric field [1] (nonlinear spin Edelstein effect), which would dominate the electric field generation of spin-polarization in a wide class of centrosymmetric nonmagnetic materials and lead to a novel nonlinear spin-orbit torque. We found that this effect is caused by the anomalous spin polarizability dipole. Furthermore, our first-principles calculations predicted significant spin generation in hcp metals and also in transition metal dichalcogenide monolayers. Finally, given the current enormous interest in orbtroinics, I will also report unpublished results of our first-principles calculations of nonlinear electric field generation of orbital magnetization (nonlinear orbital Edelstein effect) as well as linear electric field induced orbital Hall effect.

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References

1. C. Xiao, W. Wu, H. Wang, Y.-X. Huang, X. Feng, H. Liu, G.-Y. Guo, Q. Niu and S. A. Yang, *Phys. Rev. Lett.*, **2023**, *130*, 166302.