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Optical effects of spin currents in semiconductors[1]

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BANG-FEN ZHU, Department of Physics and Institute of Advanced Study, Tsinghua University, REN-BAO LIU, Department of Physics, The Chinese University of Hong Kong – We predict the linear and second-order nonlinear optical effects of spin currents in semiconductors, based on systematic symmetry analysis and microscopic calculations with realistic models [1, 2]. By an analogue to the Ampere effect and Oersted effect, we conceived and verified that a spin current can be coupled to a "photon spin curren" carried by a polarized light beam, which causes sizeable Faraday rotation without involving net magnetization. Furthermore, a spin current can have a strong second-order nonlinear optical effect with unique polarization-dependence due to the special symmetry properties of the spin current. In particular, for a longitudinal spin current, in which the spins point parallel or anti-parallel to the current direction is a chiral quantity, a chiral sum-frequency effect will be induced. The second-order optical effects of spin currents have been experimentally verified immediately after the theoretical prediction [3]. These discoveries represent new phenomena in magneto-optics, with potential spin-photonic applications. They bring new opportunities to research of spintronics and may also facilitate research of topological insulators where the edge states form pure spin currents. References:

[1] J. Wang, B. F. Zhu, and R. B. Liu, *Phys. Rev. Lett.* 100, 086603 (2008); see also Erratum, *ibid* 101, 069902 (2008)
[2] J. Wang, B. F. Zhu, and R. B. Liu, *Phys. Rev. Lett.* 104, 256601 (2008).
[3] L. K. Werake and H. Zhao, *Nature Physics* 6, 875 (2010).

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