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Spin-Hall effects in metallic antiferromagnets.[1]

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Materials possessing new parameters for efficient and tunable spin Hall effects are being explored, among which antiferromagnets have become one of the most promising candidates. Two distinct properties of antiferromagnets are the microscopic spin magnetic moment ordering and the intrinsic anisotropy. Thus the natural question arises whether these two unique features of antiferromagnets can become new degrees of freedom for tuning their spin Hall effects. We performed experimental studies using spin pumping and inverse spin Hall detection on prototypical CuAu-I-type metallic antiferromagnets, PtMn, IrMn, PdMn, and FeMn, in which we observed increasing spin Hall effects for the alloys with heavier elements included[2]. In particular, PtMn shows a large spin Hall effect that is comparable to Pt. We also demonstrated that the spin transfer torques from the antiferromagnets are large enough to excite ferromagnetic resonance of an adjacent ferromagnetic layer. We conclude that the sign and magnitude of the spin Hall effects in these antiferromagnets are determined by the atomic spin-orbit coupling of the heavy elements (e.g. Pt and Ir) as well as the large spin magnetic moments of Mn. In addition, by using epitaxial growth, we investigated the influence of the different crystalline and magnetic orientations on the anisotropic spin Hall effects of these antiferromagnets. Most of the experimental results were further corroborated by first-principles calculations, which determine the intrinsic spin Hall effect contribution and suggest pronounced anisotropies. Thus metallic antiferromagnets may become an active component for manipulating spin dependent transport properties in spintronic concepts[3].

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[2]W. Zhang *et al*, Phys. Rev. Lett. 113, 196602 (2014); Phys. Rev. B 92, 144405 (2015).

[3]This work was done in collaboration with: M. Benjamin Jungfleisch, Frank Freimuth, Joseph N. Sklenar, Wanjun Jiang, John E. Pearson, Yuriy Mokrousov, John B. Ketterson, and Axel Hoffmann