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Theory of unidirectional spin Hall magnetoresistance in heavy-metal/ferromagnetic-metal bilayers.[1] SHULEI ZHANG, GIOVANNI VIGNALE, Department of Physics and Astronomy, University of Missouri — Recent experiments have revealed a unidirectional spin Hall magnetoresistance (USMR) effect in metallic bilayers consisting of a heavy-metal (HM) and a ferromagnetic-metal (FM). Modulation in the longitudinal resistance of the bilayer has been observed when reversing the direction of either the applied in-plane current or the magnetization of the FM layer. In this work, we attribute the USMR effect to the modification of conductivity by spin accumulation induced by spin Hall (SH) effect, which may be best understood by thinking of the spin accumulation at the FM side as an artificial FM layer. In analogy to the current-in-plane giant-magnetoresistance effect, change in longitudinal resistance is expected when the "magnetization" of the artificial FM layer switches from parallel to antiparallel (or vice versa) to that of the "natural" FM layer. The nonlinear character of the magnetoresistance arises from the fact that "magnetization" of the artificial FM layer is generated by the electric current itself via the SH effect. An explicit expression for the USMR is derived, and the numerical estimation is in order of magnitude agreement with the experimental observations. We also discuss possible ways to control the sign and magnitude of the effect.

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Shulei Zhang
Department of Physics and Astronomy, University of Missouri

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