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GMAG PhD Dissertation Research Award: The Planar Nernst and Seebeck Effects in Ferromagnetic Metal Films with In-Plane Thermal Gradients

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Recently, the spin Seebeck effect (SSE) has attracted a great deal of attention as one possible source of pure spin currents. In response to a thermal gradient (∇T), the SSE is thought to produce a pure spin current detectable by measuring a transverse voltage (V_T) generated by the inverse spin Hall effect. However, recent work on spin-dependent transport in thin film nanostructures supported by bulk substrates suggests that early SSE experiments may have been strongly affected by unintended ∇T through the supporting substrates. They may also have been affected by thermoelectric effects generated from planar thermal gradients such as transverse thermopower, also known as the planar Nernst effect (PNE), in which a V_T develops in response to a ∇T applied in the plane of a film with in-plane magnetization. In this talk, we present the first results from experiments designed to probe the SSE and related effects such as the PNE and longitudinal thermopower in 20 nm thick nickel and permalloy thin films deposited on suspended Si-N platforms. In our experiments, the background thermal conduction of the 500 nm thick platforms is at least 1000x smaller than the bulk substrates used previous experiments, thus confining ∇T to the plane of the film. The results exhibit the $\sin\theta\cos\theta$ angular dependence predicted by the PNE, where θ is the angle between film magnetization and thermal gradient, rather than the $\cos\theta$ dependence expected from SSE predictions. We demonstrate that the magnetic field dependence of the PNE, anisotropic magnetoresistance, and longitudinal thermopower (α) is generated by spin-dependent scattering and present results confirming the Onsager reciprocity between α and the Peltier coefficient. Finally, we present an upper limit for the SSE coefficient in our experiment that is at least an order of magnitude smaller than previously reported by experiments conducted using bulk substrates. I would like to thank my collaborators Barry L. Zink and Matthew R. Pufall and gratefully acknowledge support from the NSF CAREER Grant No. DMR-0847796.