Anomalous Nernst Effect Induced Terahertz Emission in a Single Ferromagnetic Film

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Abstract— First discovered in 2004, a single ferromagnetic (FM) nanofilm under the femtosecond (fs) laser pump can generate THz pulses, whose origin was then attributed to the magnetic dipole radiation induced by ultrafast demagnetization [1], which was widely adopted as the exclusive mechanism in the past two decades. Most recently, some experiments showed that the THz signals from a single FM nanofilm changes its sign under sample flipping, being quite different from the behavior of ultrafast demagnetization, which was intuitively attributed to ultrafast anomalous Hall effect (AHE) [2]. Despite the fact that the THz emission from a single FM film is quite important for the study of ultrafast spin dynamics and the reveal of novel spin/orbit effect, and the development of high performance THz emitter [3–5], its underlying mechanism seems still not well understood.

Here, by developing a bidirectional pump-THz emission spectroscopy and associated symmetry analysis method, we set a benchmark for the experimental distinction of THz emission induced by various mechanisms. Our results unambiguously unveil a new mechanism — anomalous Nernst effect (ANE) induced THz emission due to the ultrafast temperature gradient created by femtosecond laser. We raise an exclusive method by inspecting and comparing the sign of THz/ANE/AHE signals, and cocluded that the AHE contribution is quite small which could been neglected. We further develop a quantitative method to separate THz signals from various contributions and find that the ANE induced mechanism is dominant within a certain thickness range. Our work not only clarifies the origin of the ferromagnetic-based THz emission, but also offers a fertile platform for investigating the ultrafast opto-magnetism and THz spintronics [6].

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