Erratum: Transverse surface modes in ferromagnets: Coupled $\vec{M}$ and $\vec{m}$ [Phys. Rev. B 99, 104435 (2019)]

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The original paper neglected to mention that its predicted transverse response is only one of three possible forms in the literature and that a generalization of Zhang's longitudinal magnon drag effect [1] to the transverse case should permit one to distinguish which of the three is correct.

This transverse response of a ferromagnet is perhaps the most disputed fundamental topic in spintronics. To be specific, consider an incident spin current whose spin polarization has a component normal to the ferromagnet's magnetization $\vec{M}$.

Model 1, an "immediate-adjustment" model, is due to Slonczewski [2] (see also Berger [3]). For it, the spin component normal to $\vec{M}$ adjusts immediately at the interface, thus, redefining $\vec{M}$.

Model 2 is an "extended-adjustment" model with a single exponential length. It was developed by Zhang *et al.* [4] using an *s-d* model for dc spin transfer across a normal metal-ferromagnetic metal interface. It was preceded by the *s-d* model of Silsbee *et al.* [5], who considered microwave frequency spin transfer to a normal metal from an adjacent ferromagnet in resonance. Here, $\vec{M}$ is considered to be fixed, but there is an exponentially varying mode of transverse $\vec{m}$.

Model 3 also is an extended-adjustment model. It employed a Fermi-liquid picture and irreversible thermodynamics for a conducting ferromagnet to obtain the equations of motion for $\vec{M}$ and $\vec{m}$ in bulk and for flow across interfaces [6] and our paper. Such a response is implicit in the work of Zhang *et al.* (ZLZA) [7] which used a Fermi-liquid model but did not employ irreversible thermodynamics. In Model 2, if $\vec{M}$ were permitted to vary, the response would be that of Model 3.

An exchange between Slonczewski and ZLZA [8,9] emphasized the disagreement between the immediate-adjustment and the extended-adjustment models. Slonczewski employed equilibrium ideas [8] whereas ZLZA in addition employed statistical ideas related to irreversible thermodynamics [9].

Note that Zhang's longitudinal magnon drag effect [1] has been observed experimentally [10–12]. A generalization to the transverse case should permit one to determine which model is correct.

The proposed experiment is given in Fig. 1, taken from our paper. That work did not note its significance relative to the three models. If the ferromagnetic insulator yttrium iron garnet (YIG) thickness d is varied, Model 1 would be independent of d, Model 2 would depend on d with a single complex exponential, and Model 3 would depend on d with two complex exponentials. In YIG, the experimental values for the longitudinal exponential decay length is on the order of 10 μm [10]; we predict the transverse decay lengths in YIG to be much shorter on the order of 2–10 nm.

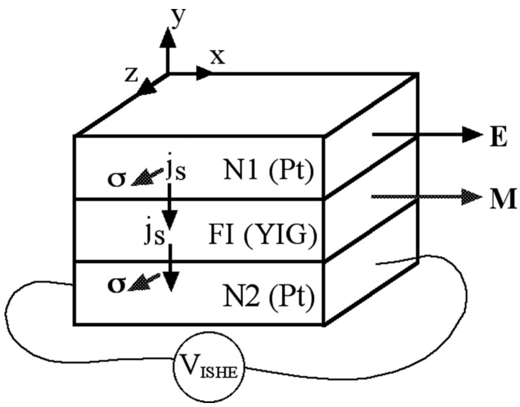

FIG. 1. Proposed transverse magnon drag experiment with three layers. $\vec{E}$ in the upper layer is driven by a source voltage and, by the spin Hall effect, produces the spin current $\vec{j}_{m,y}$ (j_s in the figure with σ for the spin accumulation $\vec{m}$). V_{ISHE} is the inverse spin Hall effect voltage that is measured across the bottom layer. The orientation of $\vec{M}$ is appropriate to the proposed transverse magnon drag effect. In the already-observed longitudinal magnon drag effect, $\vec{M}$ points along z from the original paper.

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