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Thermomagnonic spin transfer and Peltier effects in insulating magnets[1]

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The recent discovery of the spin Seebeck effect [1] in metals, insulators and semiconductors stimulated development of spincaloritronics [2]. The possibility of measuring the Onsager reciprocal spin Peltier effect has been investigated recently as well. In our theoretical work [3], we study the fictitious electromagnetic fields induced by magnetic textures which may offer an alternative route for observing the spin Peltier effect. Particularly, in an insulating ferromagnet a moving magnetic texture should effectively drive the spin (wave) current which in turn should lead to the heat current by the spin Peltier effect. We further study the coupled magnon energy transport and collective magnetization dynamics in ferromagnets with magnetic textures. We conclude that the analogy between the fictitious electromagnetic fields and real fields should lead to magnonic counterparts of such effects as the Hall effect, the Ettingshausen effect, the Nernst effect, and the Righi-Leduc effect. By constructing a phenomenological theory based on irreversible thermodynamics, we describe motion of domain walls by thermal gradients and generation of heat flows by magnetization dynamics. From microscopic description based on magnon kinetics, we estimate the transport coefficients and analyze the feasibility of energy-related applications (e.g. nanoscale heat pumps [4]) in insulating ferromagnets, such as yttrium iron garnet and europium oxide. Our estimates show that the viscous coupling effects between magnetization dynamics and magnon flows can be strong in materials with low spin densities (e.g. dilute magnetic systems) and narrow domain walls, which can allow the magnonic manipulation of magnetization dynamics and heat pumping.

[1] K. Uchida et al. Nature 455, 778 (2008).
[2] G. E. W. Bauer, A. H. MacDonald, S. Maekawa, Solid State Commun. 150, 459 (2010).
[3] A. A. Kovalev and Y. Tserkovnayk, arXiv:1106.3135.
[4] A. A. Kovalev and Y. Tserkovnyak, Solid State Commun. 150, 500 (2010).

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