Thermally excited magnonic transport through temperature steps and interfaces

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A new step towards energy efficient spintronic devices is substituting charge currents with pure spin currents for which studies of spin wave transport are needed. In this work we explore how spin waves are generated via thermal excitation and how their transport can be controlled by adjusting the system parameters and thus controlling characteristic properties like magnon accumulation at the vicinity of the temperature step. We investigate a simple-cubic ferromagnet and a bilayer consisting of a ferromagnet and a layered antiferromagnet with both ferromagnetic and antiferro- magnetic coupling at the interface combined with a temperature gradient. By using these simple models, we find criteria that are required to allow and block the transport of spin waves that are generated on one side of the material with a temperature step to the adjacent material with lower or no temperature.

In the simple cubic ferromagnet, finite temperature is applied in half of the material and the other half is kept at lower or 0K temperature. Due to this temperature difference a non-equilibrium is created in the magnon density generating more spin waves in the hotter part than in the colder part and thus there will be a transport due to diffusion of magnons from the densely populated (hotter) side to the less populated (colder) side, resulting in a net spin current flowing from the hotter to the colder side as is seen from the local magnetization profile after an initial relaxation. Far away from the temperature step the local magnetization resembles the equilibrium value but near the temperature step deviations appear. It is seen that the magnon accumulation around the temperature step and the propagation length are inversely proportional to the Gilbert damping constant and also depends on the magnitude of the temperature step.

In the bilayer, the situation is different where special care is to be taken to allow the spin wave that is generated in the ferromagnet to travel to the antiferromagnetic side via the interface. We study the dispersion relations of both the ferromagnet and the antiferromagnet separately to find out the exchange and the anisotropy values which correspond to allowed modes in both the materials. From the magnon accumulation profile, it is seen that the magnon transport is reduced in case of antiferromagnetic coupling at the interface comparing with that in ferromagnetic interfacial coupling.

References:

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