Spin thermoelectric effects in quantum dots coupled to magnetic insulators

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Recent advances in magnonics have shown the possibility for electronic components based on spin wave transport only. One of the greatest advantages of magnon currents over electronic currents is the fact that the former do not induce Joule heating. However, magnons propagating in ferromagnetic or ferrimagnetic insulators are strongly dependent on external magnetic fields, which can be disadvantageous. In order to remedy this, recently a lot of attention is paid to antiferromagnetic systems for active applications in spintronics – in contrast to traditional passive role as pinning layers in various magnetoresistive effects[1]. One of the possibilities for greater control over antiferromagnetic properties is by using so-called synthetic antiferromagnets which consist of ferromagnetic layers with opposite magnetization separated by metallic or insulating spacers[2]. Important role in such structures is played by interfaces between composite layers, which can introduce additional complex effects. Instead, one could investigate simplified interfaces such as quantum dots, which allow for electrical control over such parameters as energy level or coupling, allowing energy and spin filtering of currents.

Transport of magnons through quantum dots coupled to ferromagnetic insulators has been investigated in sequential and cotunneling regimes[3–5]. It has been shown that such systems can be used as elements in novel electronic circuits converting spin currents to electric currents and *vice versa* and work as efficient heat engines. Here I investigate theoretically thermally-induced transport of spin-wave quanta through double quantum dots coupled to two insulating ferromagnets and ferromagnetic metals. In particular I consider the case of antiparallel magnetization of ferromagnetic insulators, where the system can imitate a synthetic antiferromagnet. I show that by varying gate voltages of the dots and interdot coupling such system allows for greater control over spin current conversion.

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[1] V. Baltz et al., *Antiferromagnetic spintronics*, Reviews of Modern Physics **90**, 015005 (2018).
[2] R. A. Duine et al., *Synthetic antiferromagnetic spintronics*, Nature Physics **14**, 217 (2018).
[3] B. Sothmann and M. Büttiker, *Magnon-driven quantum-dot heat engine*, Europhysics Letters **99**, 27001 (2012).
[4] Ł. Karwacki et al., *Magnon transport through a quantum dot: Conversion to electronic spin and charge currents*, Physical Review B **92**, 235449 (2015).
[5] Ł. Karwacki, *Magnon cotunneling through a quantum dot*, Journal of Magnetism and Magnetic Materials **441**, 764–768 (2017).