Efficient cooling with hot magnons

E. Siuda[1] and P. Trocha[1]

[1] *Institute of Spintronics and Quantum Information, Faculty of Physics, Adam Mickiewicz University in Poznań*

The advent of nanotechnology allowed for investigation of behaviour of particles and quasi-particles in the smallest possible scale. In particular, systems in which different type of particles interact have been a subject of extensive studies. It was shown that such hybrid systems exhibit novel phenomena due to the interplay between different statistics governing the behaviour of the particles [1,2]. What is more, investigation of nanoscale hybrid systems proved to be worthwhile due to their potential for application. Number of heat engines, spin current converters, refrigerators and other devices have been already proposed [3-6].

We present a nanoscale refrigerator composed of two ferromagnetic metals and a magnetic insulator coupled to a quantum dot. By applying temperature gradient to the metals an imbalance in the occupations of the electronic states is created. This leads to the flow of electrons from hot to cold terminal. However with the energy input from outside it is possible to force the net current of electrons from above of Fermi level (hot electrons) to flow in the opposite direction with electrons from below Fermi level (cold electrons) still flowing in the direction of the temperature gradient. This leads to the cooling of the electrons in the cold lead - phenomenon called *cooling by heating* [7]. In the system under study one of the metals is cooled by the help of the outside source of the energy delivered by magnons coming from the magnetic insulator. The inclusion of quantum dot allows the transport to take place through discrete level which has a beneficial influence on the efficiency of the cooling. We investigate the flow of heat in the system and calculate coefficient of performance of such a device for various system's parameters.

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