15.05.2018

Abstract of the doctoral dissertation

Thermoelectric transport properties of nano-structures based on quantum dots

The results of the research presented in this dissertation indicate significant differences in the thermoelectric properties between macroscopic and quantum dots based nano-systems. It is the consequence of the existence of a discrete energy spectrum of small structures and the tunneling phenomena occurring in them.

The thesis presents results for two different structures consisting of quantum dots and metallic electrodes. First system consists of two quantum dots connected parallelly to two electrodes with a possible temperature difference between them. The second one is a thermoelectric nano-device consisting of one hot and two cold electrodes. In this system each cold electrode is connected to hot one via separate quantum dot.

To analyze the first system (chapter 3), master equation method has been applied. With this method the physical quantities like electrical and thermal conductivity, thermopower and figure of merit have been calculated in the linear approximation. The figure of merit describes thermoelectric efficiency of the device and turns out to be usefull charcteristics of the bulk materials. The power and the efficiency in nonlinear regime have been calculated. The

results show that high figure of merit value does not necessarily mean that a given system would be a good thermoelectric engine (chapter 4). Additionally, application of the magnetic field induces spin currents in the system. Both, the spin current and spin thermopower have been presented.

To describe the second system (chapter 5), the non-equilibrium Green function method has been used. With this method, calculations of electric and heat current occurring in the system have been performed. Based on these results, power and efficiency were determined. Results show power of the device at optimal work voltage and corresponding to this power efficiency. Influence of asymmetries in the couplings and temparatures of cold electrodes have also been considered and shown to have negligible effect on the maximal power and efficinecy of the device.

Additionally, dissertation includes a chapter presenting the methods that were used in this thesis to describe transport phenomena (chapter 2). Those methods are master equation method, Green function method and used in both systems Landauer method.

Barbara Szukiewicz