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Thermal electricity in strongly correlated multilayers

James Freericks[1], Veljko Zlatić[2]

[1] *Department of Physics, Georgetown University, Washington, DC 20057, U.S.A.*
[2] *Institute of Physics, Zagreb, Croatia*

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In designing novel thermoelectric devices, much effort has been spent on investigating how to improve the properties of bulk devices. Here, we focus on examining multilayered nanostructures for two reasons: (i) they allow one to "quantum engineer" the electronic structure of the device and (ii) the nanoscale interfaces should provide localization to phonon transport. We show, via an explicit example of a metal–Mott-insulator–metal device, how one can get large thermoelectric response from nanoengineering two materials that have no thermoelectric response in the bulk. This work implies that by using multilayered systems, one has the potential to create interesting thermoelectric devices out of materials that might not have been considered as viable thermoelectrics in the past.

Our formal development includes a number of elements. We describe how to perform (all electronic) calculations of transport in multilayered nanostructures composed of metallic and strongly correlated components. We use the inhomogeneous dynamical mean-field theory formalism to approach the problem and we give examples of solutions for both the Falicov-Kimball model and the Hubbard model. We show how one can derive the linear response transport of charge and heat through such a device and also discuss the roles of electronic charge reconstruction and vertex corrections.

We end with a brief discussion of what happens in a metal–Mott-insulator–metal sandwich when the Mott insulator is described by the Hubbard model, which has Fermi liquid behavior for small interaction strength. At low temperatures, the system can become conducting with what is anticipated to be highly nonlinear behavior.

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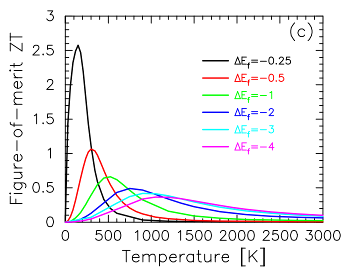

Figure 1: Figure of merit of a metal–Mott-insulator–metal device as a function of temperature for different chemical potential mismatches (from Ref. [3])

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