Heat rectification through single and coupled quantum dots

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We study heat rectification through quantum dots in the Coulomb blockade regime using a master equation approach. We consider both cases of two-terminal and four-terminal devices. In the two-terminal configuration, we analyze the case of a single quantum dot with either a doubly-degenerate level or two non-degenerate levels. In the sequential tunneling regime we analyze the behaviour of heat currents and rectification as functions of the position of the energy levels and of the temperature bias. In particular, we derive an upper bound for rectification in the closed-circuit setup with the doubly-degenerate level. We also prove the absence of a bound for the case of two non-degenerate levels and identify the ideal system parameters to achieve nearly perfect rectification. The second part of the paper deals with the effect of second-order cotunneling contributions, including both elastic and inelastic processes. In all cases we find that there exists ranges of values of parameters (such as the levels' position) where rectification is enhanced by cotunneling. In particular, in the doubly-degenerate level case we find that cotunneling corrections can enhance rectification when they reduce the magnitude of the heat currents. For the four-terminal configuration, we analyze the non-local situation of two Coulomb-coupled quantum dots, each connected to two terminals: the temperature bias is applied to the two terminals connected to one quantum dot, while the heat currents of interest are the ones flowing in the other quantum dot. Remarkably, in this situation we find that non-local rectification can be perfect as a consequence of the fact that the heat currents vanish for properly tuned parameters.

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