Restoration of the third law of thermodynamics in a nanorefrigerator model.

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A nanorefrigerator consisting of a hot and a cold electrode with particle channels formed by two quantum dots and driven by high-energy photons has been proposed by B. Cleuren et al. [1]. According to the model (shown in Fig.(1)) cold electrons condense from the cold left lead into the hot right lead, while hot electrons evaporate in the opposite direction. The article generated numerous comments due to its apparent violation of the third law of thermodynamics [2]. The unattainability principle, or dynamic third law, states that one can not cool a system to absolute zero in a finite number of steps, yet in the model presented $dT/dt \propto const$ which allows cooling to $T = 0$ K.

We have shown that when considering the discrete spectrum of the energy levels in the electrodes the third law is restored.

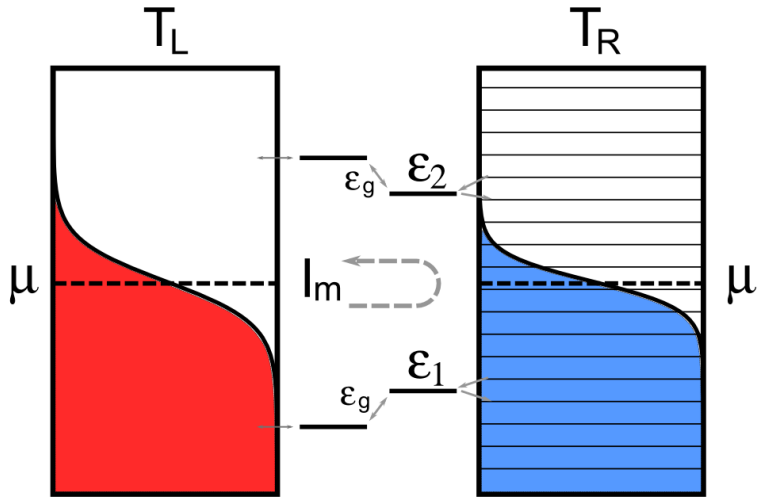

Figure 1: Diagram of the nanorefrigerator model. $T_L > T_R$ and electrons are transported through the quantum dots in the direction of the matter current I_m. Cold electrons condense into, while hot electrons evaporate out of, the right lead. Adapted from [1].

References

[1] B. Cleuren, B. Rutten, and C. Van den Broeck, Phys. Rev. Lett. **108**, 120603 (2012)

[2] A. Levy, R. Alicki, and R. Kosloff Phys. Rev. Lett. **109**, 248901 (2012)