Scattering approach to heat transport. Application to a *single*-electron emitter for chiral wave-guides

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We present a scattering matrix approach to heat transport in dynamical mesoscopic structures for non-interacting electrons [1-3]. We show quite generally existence of two effects, heat generation and heat pumping. In particular we analyze energetics [4] of a single-particle source emitting on-demand electrons and holes [5]. It turns out that the energy of emitted particles is not fixed unlike their charge. Therefore, even a regular particle flow carries a fluctuating heat. These heat fluctuations can be measured as temperature fluctuations of an attached thermometer, which in turn can be measured as the fourth cumulant of a potential if a thermometer serves simultaneously as a voltage probe. Notice the fluctuations of a heat of a regular particle flow are a feature of an essentially dynamical source and it is absent for a DC source. We analyze a heat production [4] of two subsequent single-particle sources working as a tunable two-particle source [6]. We show that unlike a charge current the heat current can be non-additive. In particular, in the adiabatic regime the heat production can be suppressed if the second source is tuned to emit a hole at the time when the first source emits an electron or vice versa. We show also that the heat generated becomes enhanced if two electrons or two holes are emitted simultaneously.

[1] M. Moskalets, M. Büttiker, *Floquet scattering theory of quantum pumps*, Phys. Rev. B **66**, 205320 (2002)
[2] L. Arrachea, M. Moskalets, *Energy transport and heat production in quantum engines*, in Handbook of Nanophysics: Nanomedicine and Nanorobotics, ed. by Klaus D. Sattler (CRC Press, Taylor & Francis Group), 38-1 (2010)
[3] M. Moskalets, Scattering matrix approach to non-stationary quantum transport, (Imperial College Press, London), 280 p. (2011)
[4] M. Moskalets, M. Büttiker, *Heat production and current noise for single- and double-cavity quantum capacitors*, Phys. Rev. B **80** 081302 (2009)
[5] G. Fève, A. Mahé, J.-M. Berroir, T. Kontos, B. Plaçais, D. C. Glattli, A. Cavanna, B. Etienne, Y. Jin, *An On-Demand Coherent Single-Electron Source*, *Science* **316**, 1169 (2007)
[6] J. Splettstoesser, S. Ol'khovskaya, M. Moskalets, M. Büttiker, *Electron counting with a two-particle emitter*, Phys. Rev. B **78**, 205110 (2008)