Time Dependent Meir-Wingreen Expression for Heat Current

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The Landauer-Büttiker formula for the particle current through a non-interacting system at stationarity is a the milestone in transport theory. It was readily generalized to the case of interacting systems by Meir and Wingreen giving the possibility of studying the effect of interactions on the transport properties of many-body quantum systems. To date there exist not an analogous expression for the energy current flowing through a many-body quantum system. Instead it is common to compute the energy current resorting to a modified version of the Meir-Wingreen which. The latter is known not to be consistent and give wrong results in certain cases, e.g. as strong coupling or in the presence of external drives. We derived an time-dependent expression for the energy current flowing through an interacting many-body quantum system coupled to different leads which is completely analogous to the Meir-Wingreen expression. With our expression the energy current flowing in/out to/from any lead can be computed. Moreover we show that our expression is completely consistent with what it is expected, namely that the sum of contributions from all leads equals the time derivative of the total energy of the many-body system even in the transient times.