Temperature profile and boundary condition in anomalous heat transport

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A framework for studying the effect of the coupling to the heat bath in models exhibiting anomalous heat conduction is described [1]. The framework is applied to the harmonic chain with momentum exchange model where the non-trivial temperature profile is calculated. In this approach one first uses the hydrodynamic (HD) equations to calculate the equilibrium current-current correlation function in large but finite chains, explicitly taking into account the boundary conditions resulting from the coupling to the heat reservoirs. Making use of a linear response relation, the anomalous conductivity exponent and an integral equation for the temperature profile are obtained. The temperature profile is found to be singular at the boundaries with an exponent which varies continuously with the coupling to the heat reservoirs expressed by the boundary conditions.

The linear response relation obtained in this work should be valid for other systems when the temperature difference is small and the system size N is large. In this regard, the Harmonic Chain with Momentum Exchange (HCME) model constitutes a landmark in which hydrodynamic boundary conditions can be obtained, the hydrodynamic equations can be solved exactly and the solution is valid for any temperature difference. Our analysis shows that a single reflection of the sound peaks can be enough to modify the asymptotic temperature profile. It would be interesting to apply the same approach to other systems and obtain the temperature profiles for systems such as Fermi-Pasta-Ulam chains or gas models.

An interesting result of the present study is the clear analytical and conceptual connection between the Lévy flight picture which was proposed for accounting for anomalous heat conduction[2,3] and the HCME. The equation governing the temperature profile is found to be the same as that obtained for the density profile of a system of particles performing Lévy flights with a length distribution decaying with a power 5/2. In the HCME the fluctuations of the sound modes are identified with the quanta of heat being carried by the Lévy flyers and the spreading of the peaks corresponds to the decrease of the flight length probability with distance.

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