ID de Contribution: **3** Type: **Non spécifié**

Macroscopic evolution of mechanical and thermal energy in a harmonic chain

jeudi 17 novembre 2022 14:00 (45 minutes)

It has been recently observed that some physical or biological systems which are maintained in a bath of constant temperature can behave in an unexpected way: in some cases the temperature stationary profile presents a maximum inside the system higher than the thermostats temperatures, as well as the possibility of uphill diffusion (energy current against the temperature gradient). This is the case for instance in mitochondria, which are present in nearly all types of human cell.

In a collaborative work with T. Komorowski and S. Olla, we derive rigourously this "heating inside the system" phenomenon from a microscopic infinite chain of coupled oscillators in contact at both ends with heat baths at different temperatures, and subject to an external force at one end. While heat flows from the thermostats, the mechanical energy produced by the force is then transformed into thermal energy by the bulk dynamics. We follow an approach based on Wigner distributions, which permit to control the energy distribution over various frequency modes and provide a natural separation between mechanical and thermal energies.

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