First-Principle Validation of Fourier's Law: One-Dimensional Classical Inertial Heisenberg Model

Henrique Santos Lima [a], Constantino Tsallis [a,b,c,d], and Fernando D. Nobre [a, b]
[a] Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil
[b] National Institute of Science and Technology for Complex Systems, Rio de Janeiro, Brazil
[c] Santa Fe Institute, Santa Fe, New Mexico, USA
[d] Complexity Science Hub Vienna, Vienna, Austria

The thermal conductance of a one-dimensional classical inertial Heisenberg model of linear size L is computed, considering the first and last particles in thermal contact with heat baths at higher and lower temperatures, T_{h} and T_{l} ($T_{h}>T_{l}$), respectively. These particles at extremities of the chain are subjected to standard Langevin dynamics, whereas all remaining rotators ($i=2, \cdots , L-1$) interact by means of nearest-neighbor ferromagnetic couplings and evolve in time following their own equations of motion, being investigated numerically through molecular-dynamics numerical simulations. Fourier's law for the heat flux is verified numerically with the thermal conductivity becoming independent of the lattice size in the limit $L \to \infty$. Moreover, the thermal conductance, $\sigma(L,T) \equiv \kappa(T)/L$, is well-fitted by a function, typical of nonextensive statistical mechanics.