From hard sphere dynamics to the Stokes-Fourier equations

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In his sixth problem, Hilbert asked for an axiomatization of gas dynamics, and he suggested to use the Boltzmann equation as an intermediate description between the (microscopic) atomic dynamics and (macroscopic) fluid models. The main difficulty to achieve this program is to prove the asymptotic decorrelation between the local microscopic interactions, referred to as propagation of chaos, on a time scale much larger than the mean free time. This is indeed the key property to observe some relaxation towards local thermodynamic equilibrium.

This control of the collision process can be obtained in fluctuation regimes. In a recent work with Thierry Bodineau and Isabelle Gallagher, we have established a long time convergence result to the linearized Boltzmann equation, and eventually derived the acoustic and incompressible Stokes-Fourier equations in dimension 2. The proof relies crucially on symmetry arguments, combined with a suitable pruning procedure to discard super exponential collision trees.

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