Dynamics of Non-Equilibrium Systems: Homoenergetic Flows for the Boltzmann Equation

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Abstract

Kinetic equations have been used for more than a century to describe the collective behavior of many-particle systems, providing a bridge between the microscopic laws of classical dynamics and macroscopic fluid mechanics. One of the most famous examples of a kinetic equation is the Boltzmann equation, which describes the evolution of a rarefied gas. In this talk, I will consider a particular class of solutions of the Boltzmann equation, known as homoenergetic solutions, which were introduced by Galkin and Truesdell in the 1960s. These are a particular type of non-equilibrium solutions of the Boltzmann equation, useful for modeling the dynamics of Boltzmann gases subjected to mechanical deformations (such as shear, expansion, or compression), thereby yielding insight into the behavior of open systems. While the well-posedness theory for these solutions shares similarities with that of homogeneous solutions, their long-time behavior differs significantly due to their far-from-equilibrium nature. In particular, their long-time asymptotics often cannot be described by equilibrium Maxwellian distributions; the landscape of possible long-time asymptotics is extremely rich and diverse. I will present different possible long-time asymptotics for homoenergetic solutions to the Boltzmann equation in the case of shear deformations. Additionally, I will discuss some conjectures and open problems in this direction.