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Microscopic theory of the stress fluctuations in materials

Understanding the dynamics arising from stress fluctuations in materials is crucial to comprehending their elastic and transport properties. A successful approach is the Hébraud-Lequeux (HL) model, introduced in the nineties [1] to study the rheological behavior of soft glassy materials, such as emulsions, foams, and colloidal suspensions. The HL model is phenomenological and relies on the distribution function that describes the probability of finding the system in a certain state of stress. This distribution function evolves over time due to the application of an external stress, which causes the particles to rearrange and deform. The model incorporates the effects of both elastic and viscous forces, as well as the effects of thermal fluctuations. The Hébraud-Lequeux model has been used to study a variety of phenomena, including the glass transition, shear thinning, and yield stress. It has also been used to develop new materials with improved rheological properties.

A fundamental issue is to deduce the phenomena at the macroscale from the microscopic dynamics at the level of individual atoms and particles. The objective of this internship is to formulate a microscopic theory describing the stress fluctuations in materials. As a starting point, a simplified system made of Brownian particles will be investigated and current theoretical approaches will be explored, including the projection-operator formalism [2–5]. Such a theory aims at providing a deeper understanding of the underlying microscopic processes that give rise to macroscopic stress fluctuations entering the HL model eventually. Ultimately, we aspire to apply these theoretical insights to investigate the viscoelastic and transport properties of complex materials, such as amorphous solids and active matter.

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