The NeufDix experiment in the International Space Station: Giant Fluctuations in microgravity

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Mass and thermal diffusion processes in a liquid mixture are accompanied by non-equilibrium fluctuations. The amplitude of these fluctuations at small wave vectors is orders of magnitude larger than that of the equilibrium ones [1, 2]. On Earth gravity quenches non equilibrium fluctuations of long wavelength [3, 4], while in microgravity conditions they are fully developed and span all the available length scales up to the macroscopic size of the system [5, 6]. Available theoretical models, based on linearized fluctuating hydrodynamics, provide an accurate description of the static and dynamic properties of these giant fluctuations under ideal conditions such as small gradients and stationary states [1].

The aim of the Giant Fluctuations space project is to investigate Non-EqUilibrium Fluctuations during DIffusion in In compleX liquids (NEUF-DIX), under conditions that cannot be tackled easily by theoretical models, such as transient diffusion, concentrated samples and large gradients [7]. The focus of the project is on the investigation of the non-equilibrium fluctuations in complex liquids, because of the rich phenomenology that can be attained by tuning the interactions in such systems. Since gravity quenches long-wavelength non-equilibrium fluctuations, in order to fully exploit the scale-free behavior of the fluctuations we envision performing experiments under microgravity conditions. The project has received initial approval by the European Space Agency (ESA) and has already entered its A/B engineering development phase, with the ultimate goal of being flown on-board the International Space Station not earlier than 2020.

The proposed experiment concept considers a fluid cell containing various samples, which are diagnosed by the optical tool "Shadowgraphy", while a temperature gradient is applied onto the fluid cell in the direction of the optical beam. The particular scientific objectives of the project are related to several challenging problems that emerged during the last years, such as:

1. understanding the non-equilibrium fluctuations in a complex ternary mixture including a polymer [8],
2. understanding the non-equilibrium fluctuations in a complex ternary mixture including a polymer close to a glass transition [9, 10],
3. checking the theoretical predictions of Casimir-like forces induced by non-equilibrium fluctuations [11, 12],
4. the investigation of the onset of fluctuations during transient diffusion [13],
5. understanding the non-equilibrium fluctuations in concentrated colloidal suspensions [14], a problem also related with the detection of Casimir forces,
6. understanding the effect of non-equilibrium fluctuations on antibodies.

We envision to parallel these experiments with state of the art multiscale simulations [15, 16], as well as to fully develop the theory required for the understanding of the experimental results.

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