Active and passive microrheology in hard colloids with varying tracer size

F. Orts[1], M. Maier[2], M. Fuchs[2], G. Ortega[1], E.M. Garzón[1], A.M. Puertas[3]

[1] Departamento de Informática, Universidad de Almería, 04120 Almería, Spain
[2] Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany
[3]Departamento de Química y Física, Universidad de Almería, 04120 Almería, Spain (apuertas@ual.es)

In active microrheology, the mechanical response of a system to microscopic external stimuli is probed by monitoring a colloidal bead inserted in the system and subjected to an external force. In contrast, in passive microrheology the bead is free to diffuse through the bath due to thermal and density fluctuations[1]. The connection between active and passive microrhelogy relies on the validity of the linear response approximation[2]. In this presentation, we will test this link with simulations and theory in hard colloids using tracers of different sizes. In the Langevin dynamics simulations, a system of quasi-hard spheres is considered with a single tracer. Tracer sizes up to 8 times larger than the bath particles are studied. For the mode coupling theory, a binary mixture of hard spheres is considered using the Percus-Yevick approximation of the static structure factor.

The effective drag coefficient calculated by the steady (long time) velocity of the tracer in active microrheology shows a linear regime for small forces, with a constant value which agrees with the inverse self diffusion coefficient measured in passive microrheology. To clearly observe this, a study of finite size effects is necessary to identify the appropriate system sizes. Linear response not only determines the agreement of these two long-time quantities, but also of the time dependent tracer displacement and velocity with mean squared displacement and integral of the velocity autocorrelation function, respectively. These relationships are also confirmed by the simulations for small forces. For larger forces, the drag coefficient decreases, entering the non-linear regime due to force thinning similar to the shear thinning regime in bulk rheology. The effects of the moving tracer on the bath are also studied, both the structural as well as the dynamical ones. The density of bath particles around the tracer becomes non-isotropic for large forces, while for small forces, within the linear regime, it remains similar to the equilibrium one. In the non-linear regime, the oscillations of the density in front of the tracer are damped more strongly and their wavelength decreases. The bulk dynamics in the bath, however, is very slightly modified.

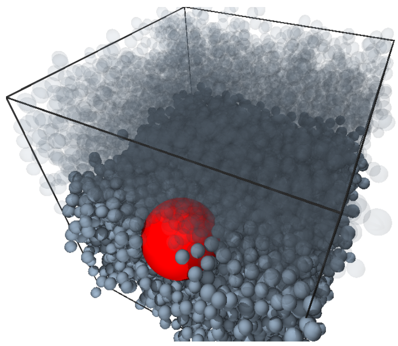

Figure 1: Snapshot of the system with a tracer six times larger than the bath particles. The particles above the tracer are made transparent for presentation purposes.

[1]E.M. Furst, T.M. Squires, *Microrheology*, Oxford University Press, Oxford (2017).
[2]F. Orts, G. Ortega, E.M. Garzón, M. Fuchs, A.M. Puertas, *Phys. Rev. E*, **101**, 052607 (2020).