Efficient detection of plastic events in emulsions simulations

M. Bernaschi[1], M. Lulli[2], M. Sbragaglia[2]

[1]National Research Council of Italy

[2]University of Rome "Tor Vergata"

Emulsions are complex systems formed by a number of non-coalescing droplets dispersed in a solvent leading to non-trivial effects in the overall flowing dynamics. Such systems possess a yield stress below which an elastic response to an external forcing occurs, while above the yield stress the system flows as a non-Newtonian fluid, i.e. the stress is not proportional to the shear. In the solid-like regime the network of the droplets interfaces stores the energy coming from the work exerted by an external forcing, which can be used to move the droplets in a non-reversible way, i.e. causing plastic events. The Kinetic-Elasto-Plastic (KEP) theory is an effective theory describing some features of the flowing regime relating the rate of plastic events to a scalar field called fluidity that can be interpreted as the inverse of an effective viscosity. Boundary conditions have a non-trivial role not captured by the KEP description. In this contribution we will compare numerical results against experiments concerning the Poiseuille flow of emulsions in microchannels with complex boundary geometries. The simulations are based on the Lattice Boltzmann (LB) methods. A suitable combination of attractive and repulsive interactions among the LB populations allow the simulation of a collection of droplets above the jamming point, displaying salient features of soft-glassy materials, including yield stress and non-local rheology. We implemented the model in a highly tuned CUDA code running on GPU. For the detection of plastic events we enhanced the code with a novel CUDA procedure for finding and comparing Delaunay triangulations that can be applied to the general problem of detecting topological changes in case of dynamic centroidal Voronoi diagrams (we recall that the Delaunay triangulation corresponds to the dual graph of the Voronoi diagram) whose generating points move in time. Possible examples of application include clustering analysis, a general tool used in many disciplines including (but not limited to) pattern recognition, computer graphics, combinatorial chemistry or the study of the behaviour of animals when they stake out a territory.

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