Quasistatic shear of foams with Cellular Potts Model simulations

F. Villemot [1]

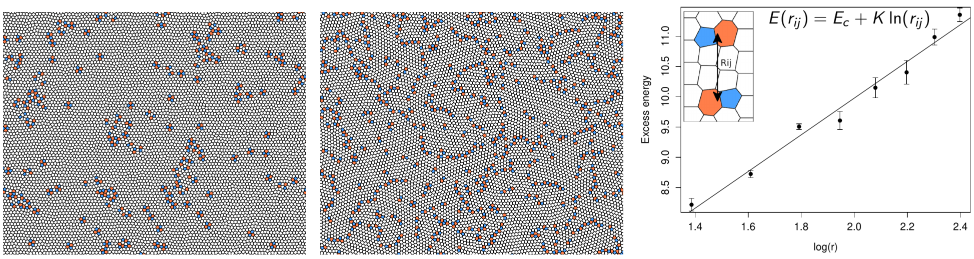
M. Durand [1]

[1] Matière et Systèmes Complexes (MSC), UMR 7057 CNRS & Université de Paris, Paris, France.

E-mail: francois.villemot@univ-paris-diderot.fr

ABSTRACT

We present a method to rigorously compute the shear modulus of foams under small strain, using the Cellular Potts Model (CPM). The CPM is widely used for simulating foam structure and dynamics, and is a lattice based modeling technique: each cell is represented as a subset of lattice sites sharing the same cell ID. Cellular domains can adopt any shape on the lattice, and the system evolves using a Metropolis algorithm. Because simulations are on a lattice, strain cannot be induced by changing the shape of the simulation box. To circumvent this issue, we apply a shear strain at the top and bottom boundaries of the box by forcing the displacement of the bubbles at these positions, which is done by adding an appropriate term in the Hamiltonian. This effectively constrains the foam between two moving plates. Our numerical method allows for rigorous simulation of quasistatic shear of foams. After testing its validity with a regular hexagonal foam, we show that the spatial distribution of defects deeply affects the small strain response of foams. When they are uniformly distributed [Fig. 1a], strain is homogeneous down to the bubble scale and elastic moduli can be evaluated. Their values are recovered independently by analyzing the interaction energy between defects [Fig. 1c]. On the other hand, when defects self-associate into long chains (generated by quenching) the strain is inhomogeneous on length scale comparable with the sample size [Fig. 1b].



(a) (b) (c)

Figure 1: (a) Foam with defects distributed uniformly. (b) Foam with defects self-organized into long chains. (c) Semi-log plot of the interaction energy of two dislocations as a function of their distance. Slope allows to extract the effective Young modulus of the medium.