Dynamic reorganization of droplets: from Foams to Phonons

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The stability and the mechanical response of monodisperse droplet packing in quasi 2d micro-channels are discussed under static and dynamic conditions. We will bridge the behavior from dense to dilute droplet packings: Very dense droplet arrangements are analogous to foam and can be controlled manipulated and described by geometrical means provided the friction is low. Reducing the droplet fraction so that the droplets are still in mechanical contact, the resulting droplet arrangements are stabilized by virtue of the Laplace pressure. Depending on the exact choice of parameter a droplet packing can have a negative compressibility separating into stable domains of higher and lower packing fraction. When flowing along a microfluidic channel these unstable droplet arrangements develop complex non-equilibrium re-arrangements similar to avalanches. Reducing the droplet fraction even further, moving droplets experience each other by dipole-like hydrodynamic interactions. Driven by these hydrodynamic interactions collective oscillations might emerge in linear trains of droplets which can be described by a phonon-type behavior.