Disordered and biological soft matter

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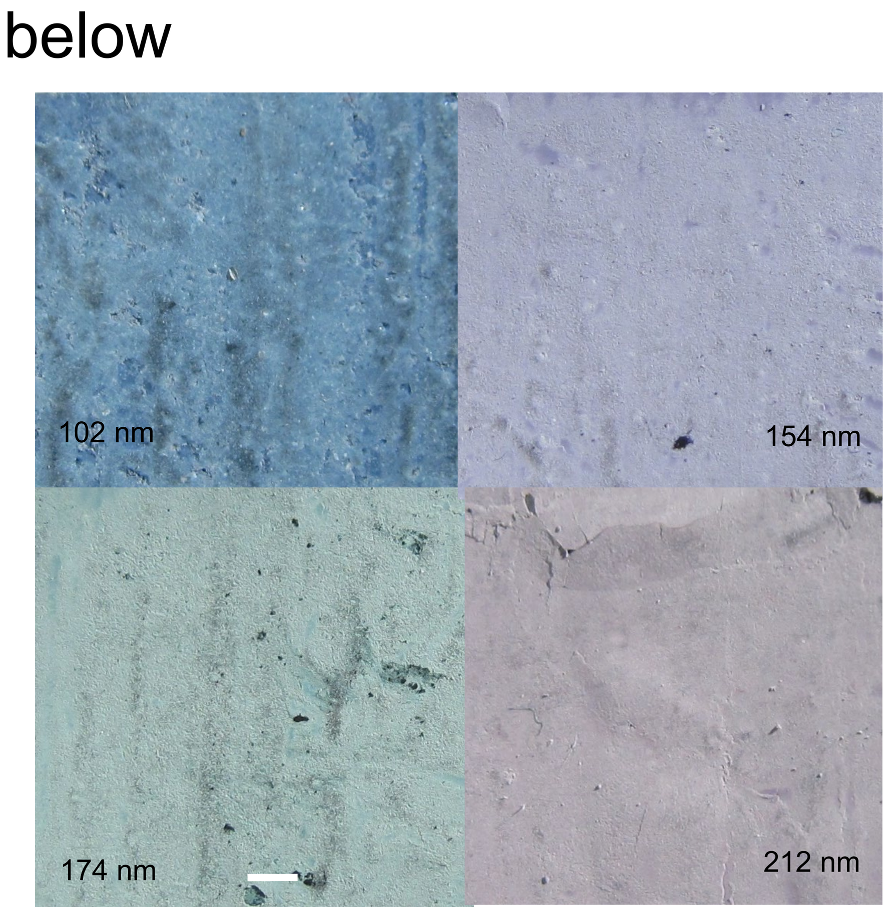
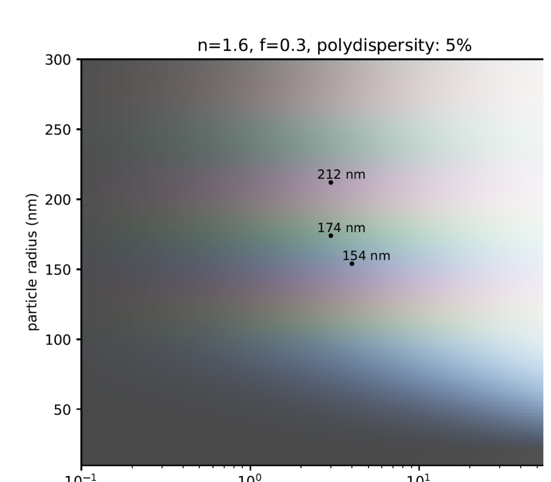
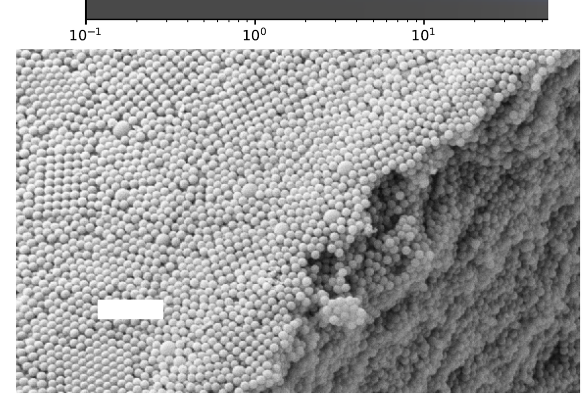
Structural colours in photonic structures

The blue of Morpho Menelaus is NOT a pigment, but rather originates in nanoscopic structures that lead to constructive interference only in a limited part of the spectrum. Changing the optical pathlength by changing the index contrast leads to a change in colour.

This can also be achieved with polystyrene or titania nanoparticles, where a theoretical description of scattering properties from single particles as well as from the disordered arrangement yiels predictions of colouration for different particle sizes and refractive indices. The predictions are borne out well experimentally for polystyrene particles as shown below



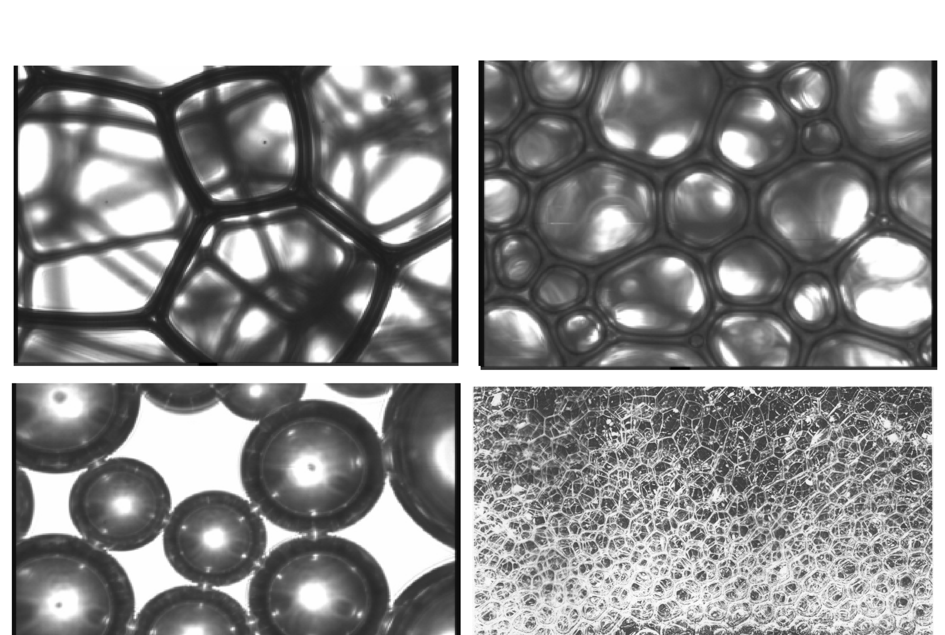




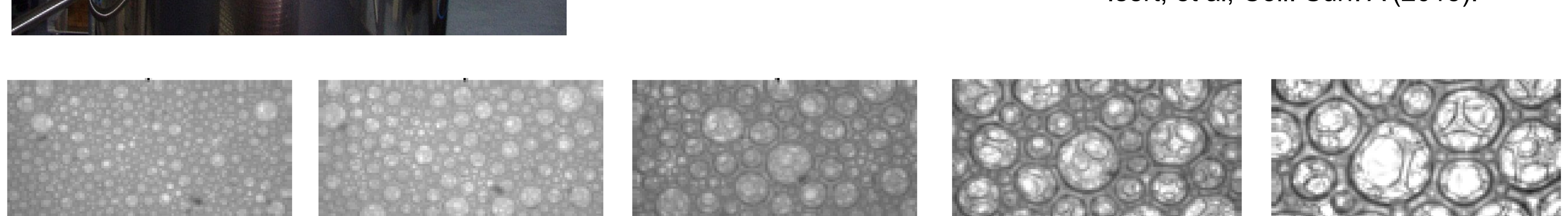
Schertel et al, Adv. Opt. Mat. (2019).

Levitated non-equilibrium systems

Many non-equilibrium systems are forced to a stable point in the absence of driving quickly by gravity. For instance, foam coarsening is masked by fluid drainage and inelastic collapse of granular gases by piling up of grains. In order to study the undisturbed long time dynamics non-equilibrium systems, they need to be levitated or studied in the space station. We use the diamagnetic properties of water and a strong magnet to levitate foams and hence study the coarsening behaviour for different amounts of liquid in the foam.

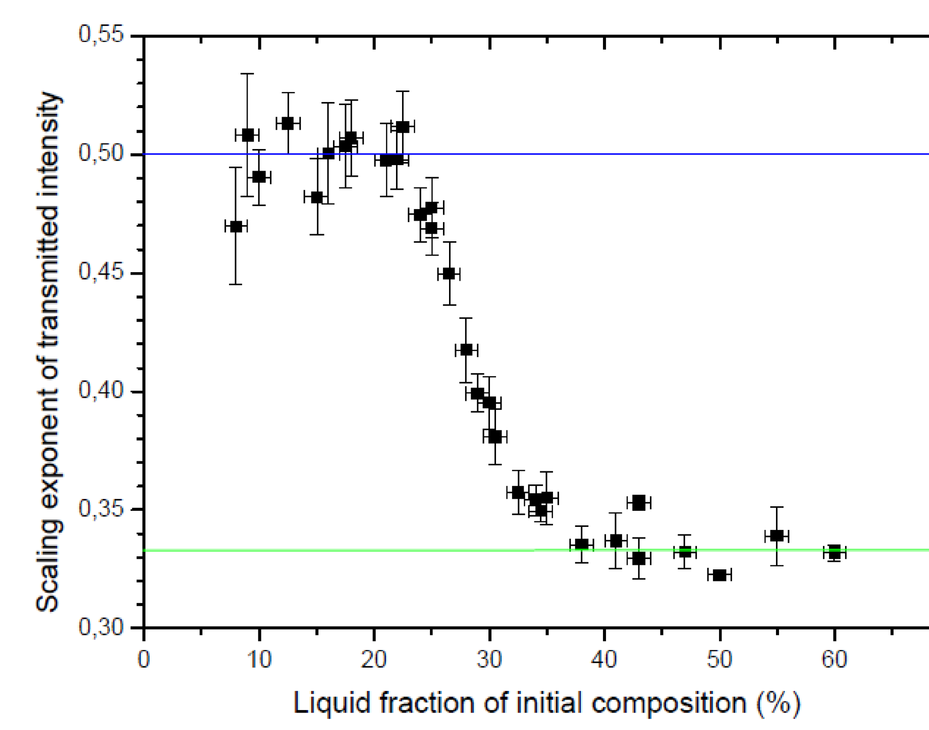


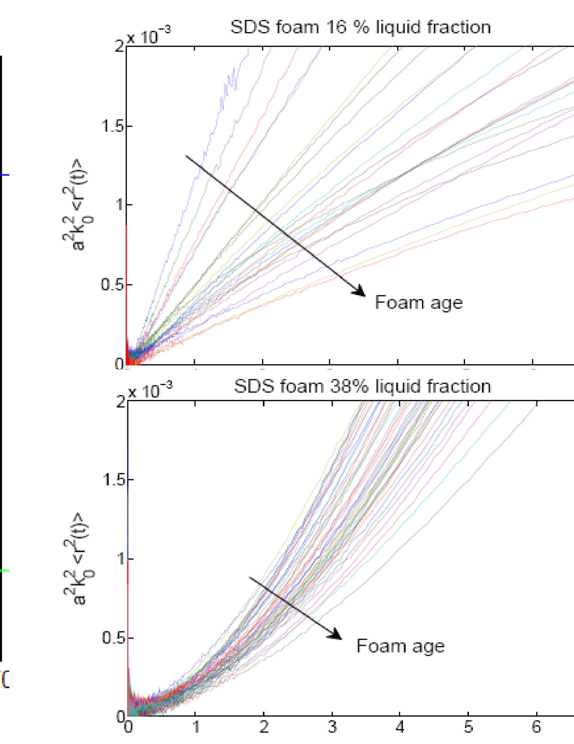
Isert, et al, Coll. Surf. A (2015).



Surface image of a foam at different tmes. The average bubble size increases as time goes on, which can be quantified and compared with the theoretical prediction of <r> ~t $^{1/2}$

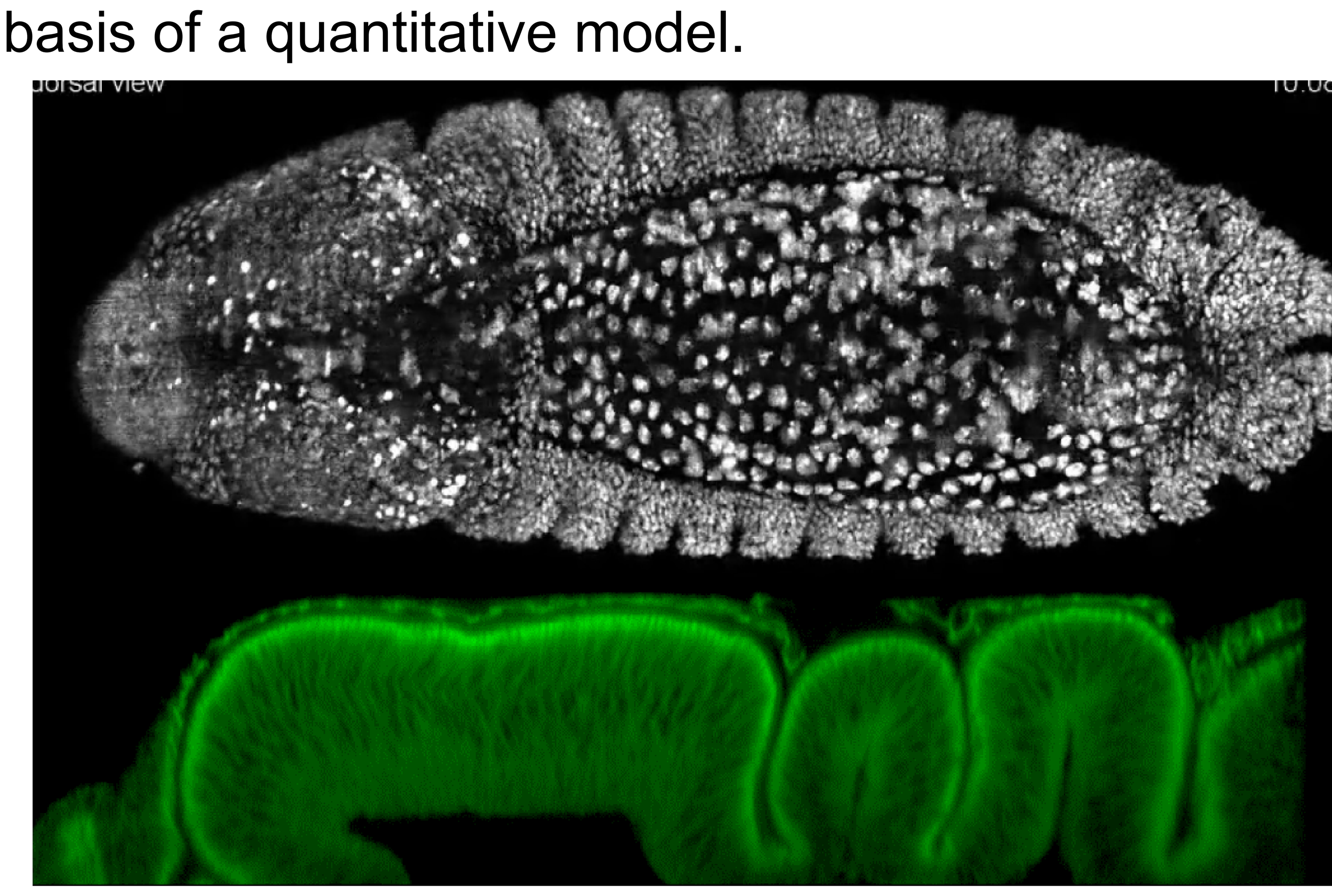
The coarsening dynamics qualitatively changes at liquid fractions of 25%, where close packing of spheres is reached. At higher liquid fractions, coarsening takes place via gas exchange in the fluid. The corresponding change in the dynamics of bubbles is also seen in diffusing wave spectroscopy.



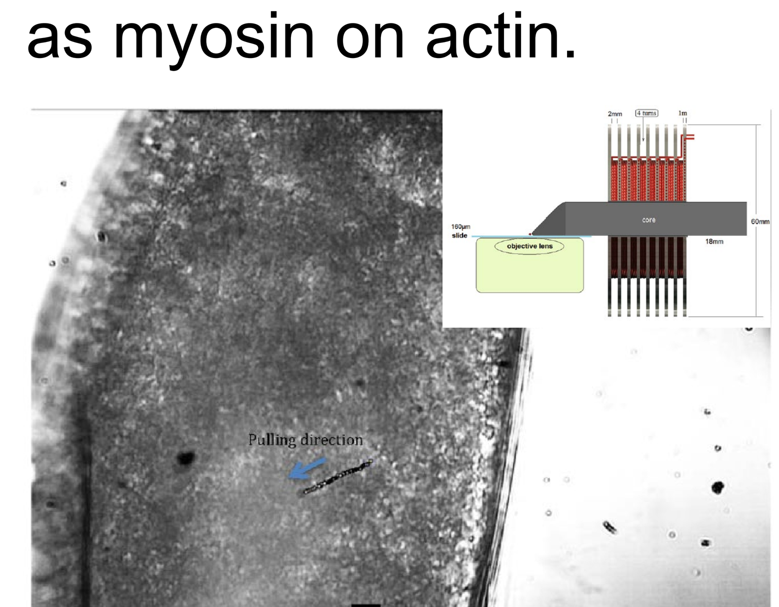


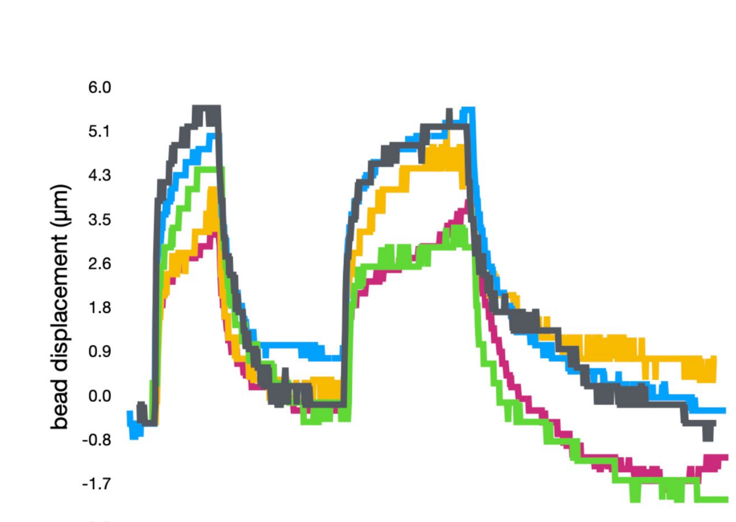
Mechanical regulation of biological development in Drosophila

Structures in tissues of embryos (such as Drosophila imaged below) are intimately governed by mechanical forces acting on the tissues during development. Studying this experimentally and theoretically needs the determination of (visco-) elastic properties of biological tissues to form the basis of a quantitative model.



In order to determine these properties, we develop methods to apply and measure forces on tissues on several different scales. One example is using a magnetic tweezer to apply forces on the scale of nN onto tissues and observe their response. Similarly, using the apparatus to measure forces actively exerted by the cells on the same scale, we determine the force patterns generated by motorproteins, such as myosin on actin.





Selvaggi, et al, Biophys. J. (2022).

Magnetic bead pulled through embryonic tissue and followed using direct imaging. In conjunction with fluorescence imaging, such pulling experiments can be performed while determining the activity of motor proteins creating the respective forces. With a pull-and release experiment, as shown on the right, the visco-elastic properties of the tissue can be determined, as well as the forces induced by actomyosin contractions.