TECHNISCHE UNIVERSITÄT DRESDEN

Soft Active Gels

Modeling, numerical simulations and new perspectives

Tuesday 11 December 2018 at 15:00, ZEU 247 (Zeuner Bau)

Cycle of seminars within the international collaboration with:

- **Sapienza Università di Roma**
- **Università degli Studi di Roma Tre**

Speakers:

- **Prof. Paola Nardinocchi (Sapienza)**
- **Prof. Luciano Teresi (Roma Tre)**
- **M.Sc. Michele Curatolo (Roma Tre)**

Organizers:

- **M.Sc. Marco Rossi (TU Dresden)**
- **Prof. Thomas Wallmersperger (TU Dresden)**

Partnership:

Info: marco.rossi@tu-dresden.de

International Speakers

ZEUNER BAU, ZEU 247, from 15:00 to 16:30
20 minutes for the talk + 10 minutes for questions

Talk 1 – 15:00

Prof.
Paola Nardinocchi
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Sapienza Università di Roma

Talk 2 – 15:30

Prof.
Luciano Teresi
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Università degli Studi di Roma Tre

Talk 3 – 16:00

M. Sc.
Michele Curatolo
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Università degli Studi di Roma Tre

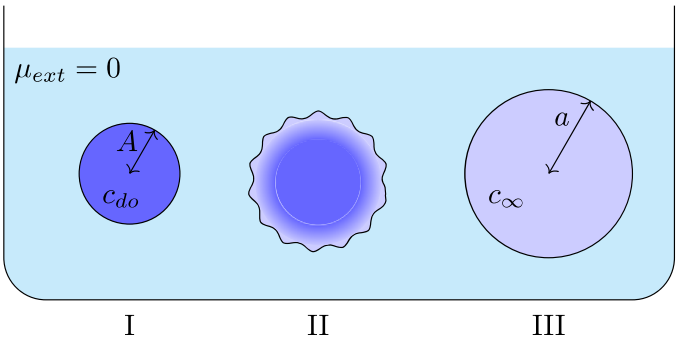
Abstract

Soft Active Materials

Soft active materials are largely employed: in Nature to realize mechanisms whose specific function is triggered by specific stimuli; in man-made devices, where deformations and displacements are triggered by a wide range of external stimuli. The effectiveness of these actuators critically depends on two elements: the capability to get prescribed changes in shape and size, and the rate of changes. Whereas the first factor concerns the equilibrium theory of swelling which is now relatively well understood, the rate of changes deals with the transient dynamic, which have received comparatively little attention despite its practical importance.

Talk 1 – 15:00 - Prof. Paola Nardinocchi

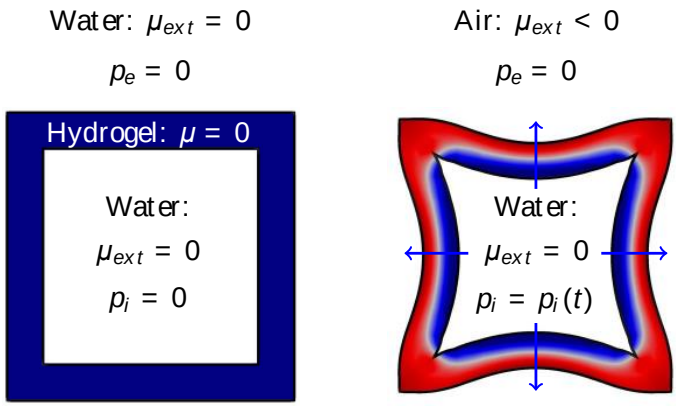
The first talk introduces the key characteristics of the swelling dynamics within the context of the stress-diffusion model presented in Ref. [1] and with reference to a simple problem: the swelling dynamics driven by solvent absorption in a hydrogel sphere immersed in a solvent bath. The transient process from dry to wet will be discussed and the onset of surface instabilities analyzed [2].



From left to right: (I) a gel sphere of radius A at the initial time; (II) at the early times; (III) at the final steady state of radius a. The blue coloring of the spheres points to different solvent concentration, uniform at initial and final states, and with a pronounced boundary layer at early times.

Talk 2 – 15:30 - Prof. Luciano Teresi

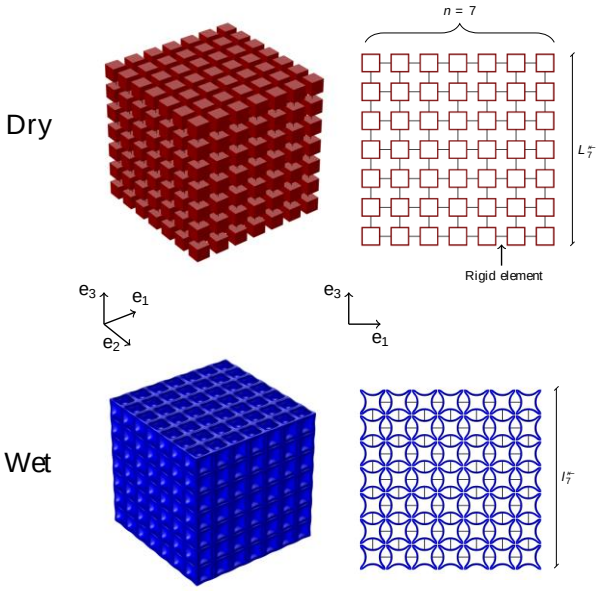
The second talk focus on a distinguished dynamics of hydrogel structures, that is, cavitation in hydrogels cavities as a tool to generate fast movements. The starting point is the observation of the cavitation–triggered catapult of fern sporangia, whose function is the realization of a perfect dispersal mechanism. The mechano–chemical processes occurring in a hydrogel structure made of a void cube, firstly embedded in water and completely wetted, and then dried through air exposition, is implemented via a finite element code. An analysis of the factors allowing cavitation pressure to form inside the cavity is proposed, to allow for precise tuning of the key geometrical and material parameters [3].



A hydrogel cube with a cavity sits in a bath, in a free-swollen, steady state; the cavity is completely filled with water (left). The same hydrogel is pulled out and exposed to air: dehydration begins and water is pumped out of the cavity by the difference in chemical potential. As the water content of the cavity reduces, the walls experience a suction pressure that yields an inward bending (right).

Talk 3 – 16:00 – M.Sc. Michele Curatolo

The third talk introduces a technique to achieve effective negative swelling into a hydrogel structure. In particular, starting from the previous discussed problem, Particularly, I show that using homogeneous and isotropic hydrogel unit cells joined by rigid connections with impermeable inner cavities is enough to achieve this phenomenon. The key feature of this method is to use specific unit cells and decompose the problem in two steps; the first concerns the final shape of a unit cell after absorption of the solvent; the second consists in creating an array with these unit cells using rigid connections realizing what it may be called a metahydrogel [4].



Swelling behavior of a cubic array composed of single unit cells filled with an ideal incompressible fluid. Top: dry state of the cubic array and its section skeleton. Bottom: wet state of the cubic array and its section skeleton.

References:

[1] A. Lucantonio, P. Nardinocchi, and L. Teresi. "Transient analysis of swelling-induced large deformations in polymer gels." *Journal of the Mechanics and Physics of Solids* 61.1 (2013): 205-218.

[2] M. Curatolo, P. Nardinocchi, E. Puntel, and L. Teresi. "Transient instabilities in the swelling dynamics of a hydrogel sphere." *Journal of Applied Physics* 122.14 (2017): 145109.

[3] M. Curatolo, P. Nardinocchi, and L. Teresi. "Driving water cavitation in a hydrogel cavity." *Soft matter* 14.12 (2018): 2310-2321.

[4] M. Curatolo. "Effective negative swelling of hydrogel-solid composites." *Extreme Mechanics Letters* (2018).