SOFT ROBOTIC MATTER
⇥ **Bas Overvelde**

The Soft Robotic Matter group focuses on research at the crossroads of soft robotics and mechanical metamaterials. Combining computational, experimental and analytical tools, the group explores how shape, nonlinearities and feedback can be harnessed to embody intelligent behavior in mechanical systems. In particular, the group works on the design, fabrication and fundamental understanding of robotic materials that are capable of autonomously adapting to – and even harnessing – variations in their environment. Along these lines, the group aims to uncover principles that help us understand how such nonlinearities and feedback can bring about complex – but useful – behavior in soft actuated systems.

Highlights

• We developed a soft hysteretic valve that can be integrated in soft fluidic circuits to achieve pulsatile and sequential activation of soft robots and devices [1].

• We built robotic matter, a physical platform to study distributed algorithms to implement learning in (material) systems with limited computational power [3].

• We mapped the occurrence of elastic multistability in prismatic metamaterials by exploring the complex energy landscape through local actuation [4].

• We worked with artists and designers to showcase our research on prismatic metamaterials to the general public [5].

Plans

We will explore new ways in which intelligence can be embodied in soft robotic devices, with the goal of making soft robots and materials that operate autonomously. We aim to not only demonstrate such principles at the macroscale, but also explore the fact that many of the proposed underlying principles are scale-independent, such that they can be applied in micro- and nanoscale (robotic) systems. Moreover, we aim to connect this fundamental scientific research with application-driven research, specifically in medical and agri-food applications, in order to have direct societal impact.

Key research items

1. L.C. van Laake, J. De Vries, S. Malek Kani and J.T.B. Overvelde, *A Fluidic Relaxation Oscillator for Reprogrammable Sequential Actuation in Soft Robots*, Matter, 5(9), 2898-2917 (2022)

2. A. Vis, M. Arfaee, H. Khambati, M.S. Slaughter, J.F. Gummert, J.T.B. Overvelde and J. Kluin, *The Ongoing Quest for the First Total Artificial Heart as Destination Therapy*, Nat. Rev. Cardiol. 19, 813-828 (2022)

3. G. Oliveri, L.C. van Laake, C. Carissimo, C. Miette and J.T.B. Overvelde, *Decentralized Reinforced Learning in Soft Robotic Matter,* PNAS, 118(21), e2017015118: 1-6 (2021)

4. A. Iniguez-Rabago, Y. Li and J.T.B. Overvelde, *Exploring Multistability in Prismatic Metamaterials through Local Actuation*, Nature Commun., 10 5577:1-10 (2019)

5. "*Edge of Chaos*", Art exhibition on world tour at WoeLab in Lomé TG, La Gaîté Lyrique in Paris FR; Cinekid in Amsterdam NL; KIKK Festival in Namur BE (Dec 2017 - Jan 2019)

Sequential activation of soft actuators using hysteretic valves (credits: Alberto Comoretto).