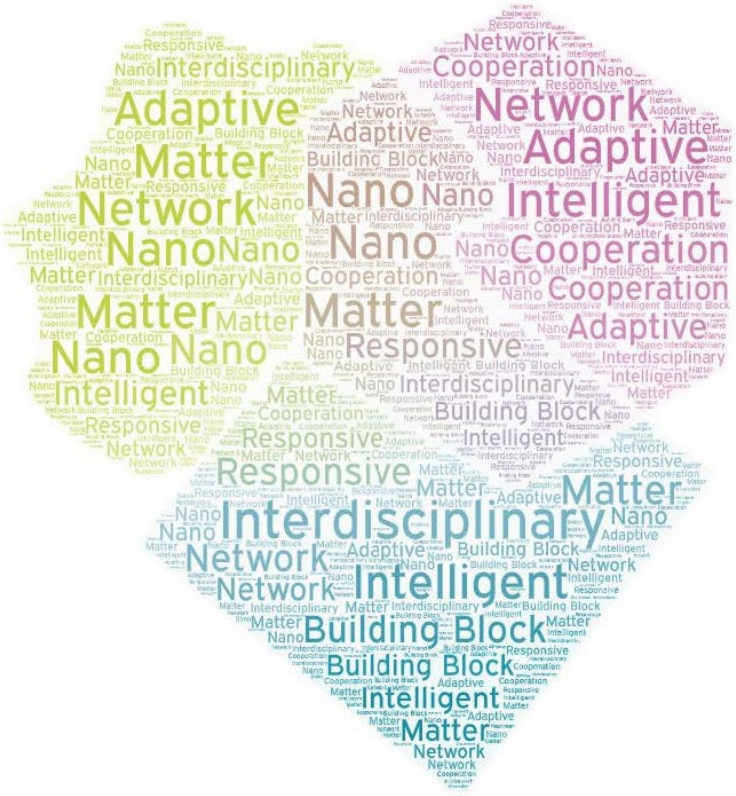
Universität Münster

Center for Soft Nanoscience

CRC 1459 INTELLIGENT MATTER

CRC 1459
Fall Colloquium 2025

November 27th 2025 | 3:00pm
Münster, Germany



Booklet of Abstracts

Program

3:00 pm

Svetlana Santer

University of Potsdam, Germany

From Molecular Actuation to Microscopic Motion

Chair: Franziska Helmrich

4:00 pm

Hanumantha Rao Vatakuri

University of Twente, The Netherlands

Designer Active Matter: From Self-propelled Particles to Active Lipid Vesicles

Chair: Jesco Schönfelder

5:00 pm

Networking with Beer & Pretzels

Please see our website www.uni-muenster.de/SFB1459/events for updates or contact crc1459@uni- muenster.de if you have any questions!

Speakers

Prof. Dr. Svetlana Santer

Institute of Physics and Astronomy
University of Potsdam
Germany

Since 2009, Svetlana Santer has been leading the Laboratory of Smart Soft Matter at the Institute of Physics and Astronomy, University of Potsdam, Germany. Her research focuses on the fundamental principles governing soft matter systems at surfaces and interfaces, with particular emphasis on the interactions between nanoparticles and polymer surfaces. Her group investigates photo-chemically induced processes, light-driven ordering phenomena at interfaces, and the motion and assembly of micro- and nanoparticles under light control.

Svetlana Santer received her Master of Science degree in Biophysics from the University of St. Petersburg, Russia, in 1996, and obtained her PhD in Macromolecular Chemistry from Ulm University, Germany, in 2000. During her doctoral studies, she explored thin polymer films and individual synthetic and biomolecules at surfaces using atomic force microscopy. In 2007, she completed her Habilitation in the field of microsystems at the Department of Microsystems Engineering (IMTEK), University of Freiburg, Germany.

Her research bridges physics, chemistry, and materials science, contributing to a deeper understanding of interfacial phenomena and light–matter interactions in soft and hybrid systems.

From molecular actuation to microscopic motion

Prof. Dr. Svetlana Santer, University of Potsdam,

Molecular self-assembly is the process in which molecules combine into superstructures held together through non-covalent interactions. Over the last decades, supramolecular chemists have perfected this art, and we can now create Gigadalton structures in which each atom is placed with angstrom precision. More importantly, the unique properties of the emerging assemblies have found their way into everyday life, like, for example, the liquid crystals in our displays. Nevertheless, biology entirely overshadows us regarding assembly with molecular building blocks. Indeed, the biological cell has the same molecular toolbox for creating structures; it also uses non-covalent interactions to hold molecules together. Biology

uses another trick. Biological structures are governed not only by non-covalent interactions but also by reactions forming covalent ones. Arguably, molecular self-assembly offers the structures; chemical reactions govern the dynamics and functions of these structures. Biological structures are sustained and regulated in the non-equilibrium regime through chemical reaction cycles that convert energy. The implications, rules, and mechanisms there are poorly understood.

Azobenzene molecules can be considered as molecular actuators that convert optical energy in mechanical work. In this talk I will show several interesting examples where azobenzene can be used in order to actuate matter on large time and length scales. In all these examples the azobenzene plays the role of a transducer that mediates between different states of size, shape, position and interfacial energy of several nano-scale soft materials.

In the first part of my talk I will show how using a home made set-up combining an atomic force microscope (AFM) and two-beam interferometry it is possible to address two major points concerning the experimental efforts in understanding surface relief grating (SRG) formation in azobenzene containing polymers: (i) how is the orientation of the electric field vector within the interfering electromagnetic fields related to the topographical pattern within the SRG; (ii) how can one measure locally the opto-mechanical forces emerging during topography change. We will discuss three distinct systems: polymer films, polymer brushes, and azobenzene containing polymer nanoparticles. [1-4]

In the second part of my talk I will show how, using azobenzene containing surfactant, [5] one can manipulate microparticles and even induce their self-propulsion when trapped at a solid/liquid interface. Depending on the applied wave length one can either disperse/remove or gather particles. The physical origin of this genuine behaviour is related to the phenomenon of light driven diffusioosmosis (LDDO). [6,7] During irradiation of a solution containing azobenzene surfactants with focused light, there is a formation of local flow at the solid/liquid interface. The corresponding hydrodynamic forces are sufficiently strong to swiftly clean the illuminated area from particles trapped at the interface. When the colloids are made into Janus particles, their self-propulsion can be initiated in the solution of azobenzene containing surfactant even under global/homogeneous illumination with blue light. We will discuss how to establish light-driven hydrodynamics as a useful and versatile tool for investigating collective motion of self-propelled particles and aggregation. At the very end of my talk I will present further examples of azo-induced actuation of soft matter. Microgel particles made light sensitive with azo-surfactants can change their volume (growing or shrinking) by up to a factor of 8 and LCST point between 32°C and 85°C in response to illumination with two different wavelengths. [8, 9]

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[9] Jelken J.; Jung S.; Lomadze N.; Gordievskaya Y. D.; Kramarenko E. Y.; Pich A.; Santer S. Adv. Funct. Mater., (2021), 2107946.

Prof. Dr. Hanumantha Rao Vatakuri

Active Soft Matter Lab
University of Twente
The Netherlands

Hanumantha Rao Vutukuri is an experimental physicist who leads the Active Soft Matter and Bioinspired Materials Design Lab at the University of Twente, with affiliations to BRAINS and the Molecules and Materials Center. He earned his Master's degree from the Indian Institute of Science, Bangalore, and his PhD from Utrecht University, The Netherlands. Before joining Twente, he was a Marie Skłodowska-Curie postdoctoral fellow at ETH Zurich, Switzerland.

His group pioneers experimental platforms that mimic life-like behaviors using synthetic systems, addressing fundamental questions in nonequilibrium physics, dynamic self-organization, and lipid membrane mechanics. His lab takes an interdisciplinary approach, integrating concepts from soft matter physics, biology, and materials science to build biomimetic systems. Their research focuses on two main directions: artificial microswimmers and active lipid vesicles, with notable contributions to the design of self-propelled colloidal particles (Nat. Commun. 2020; Sci. Rep. 2017) and active vesicle systems (Nature 2020; Nat. Commun. 2024; ACS Nano 2024; Nat. Phys. 2025).

He has been recognized with several prestigious personal grants, including an ERC Consolidator Grant (2024), NWO-M1 (2023), and a Marie Skłodowska-Curie Fellowship (2016), reflecting the originality, impact, and scientific vision of his work. Beyond research, he contributes actively to the scientific community through roles in major conference program committees, including the International Soft Matter Conference 2025 (Greece) and NWO-Physics 2025.

Designer Active Matter: From Self-propelled Particles to Active Lipid Vesicles

Prof. Dr. Hanumantha Rao Vutukuri, University of Twente, The Netherlands

Active or living materials consist of motile units that interact, communicate, and self-organize into complex structures. Such behaviors are ubiquitous in nature, ranging from flocks of birds and schools of fish to human crowds and bacterial colonies. Replicating these life-like dynamics in synthetic systems remains a major challenge across physics, chemistry, biophysics, and materials science. We use an interdisciplinary approach that integrates concepts from physics, chemistry, and biology to tackle this challenge. Our work is centred around two complementary research directions: artificial microswimmers and active lipid vesicles. Both systems are rooted in nonequilibrium physics and guided by the ambition to design adaptive, bioinspired materials.

In the first part of my talk, I will introduce our experimental toolbox of active units with programmable motion and responsiveness to local cues, including rotators, artificial flagella-like swimmers [1], and light-controlled particles whose propulsion direction can be reversed [2]. These modular, self-propelled systems mimic essential features of microorganisms and allow us to encode persistent random walks such as Lévy and Run and Tumbling motion. This platform enables precise control at the single-particle level and provides a controlled setting to investigate how local interactions give rise to emergent collective behaviors. I will then introduce our recent work on light-driven polar rods, which mimic bacterial motility and enable systematic investigation of how shape-induced alignment, steric interactions, and hydrodynamic coupling govern collective behaviors such as swarming, clustering, and active turbulence [3].

In the second part, I will focus on a minimal biomimetic system that enables us to study how lipid membranes respond to localized internal forces, similar to those generated by cytoskeletal filaments and intracellular pathogens. Here, giant unilamellar vesicles (GUVs) serve as model membranes, while enclosed self-propelled particles generate active forces from within [4]. I will show that propulsion forces as small as 0.1 pN can induce dramatic vesicle deformations and drive active membrane fluctuations. This system offers insight into how local activity shapes soft membrane dynamics. Finally, I will end by demonstrating how endocytosis-like pathways can be fully controlled by tuning membrane curvature, particle geometry, and adhesion [5]. These findings provide a framework for understanding shape adaptation in biological membranes and for designing micron-scale soft robotic systems and synthetic cells.

References:

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Photographs and images obtained from:

Svetlana Santer and Hanumantha Rao Vatakuri