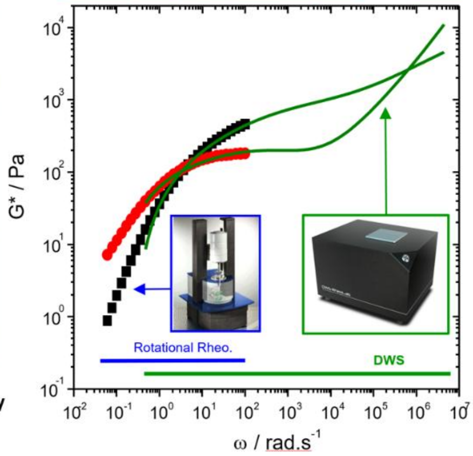
April 13th 2026 - "Microrheology: from Fundamentals to Applications"

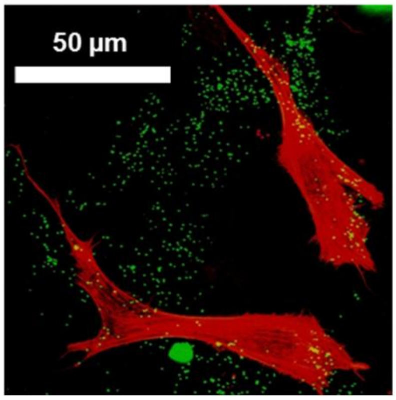
Instructors: Dr. Claude Oelschlaeger (KIT, Germany) & Dr. Manlio Tassieri (University of Glasgow, Scotland, UK)

Dr. Claude Oelschlaeger
Karlsruhe Institute of Technology

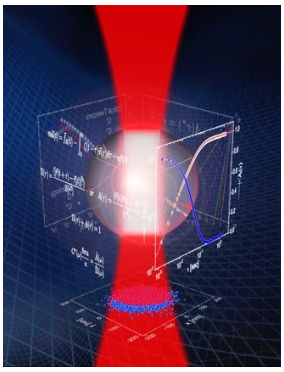
Dynamic shear moduli of a wormlike micellar solution CPCl/NaSal obatined from DWS (green)



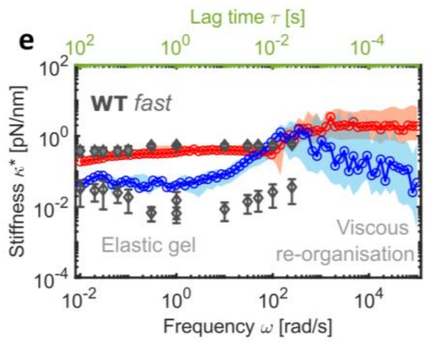
Tracer particles (green) in a HA/Coll 3D scaffold for MPT analysis. Fibroblast cells in red.



Dr Manlio Tassieri
The University of Glasgow



Schematic representation of microrheology with optical tweezers



Complex stiffness, κ(ω), as a function of frequency obtained from broadband microrheology of wild-type (WT) chromosomes. Nat Commun 16, 6399 (2025)

Microrheology has become an indispensable tool for investigating the rheological properties of a wide range of soft materials, including colloidal suspensions, polymer gels, emulsions, surfactant mixtures, and complex biological systems. Its unique capabilities make it particularly valuable in contexts where conventional rheometry fails, such as probing tiny sample volumes, measuring delicate biomaterials, or resolving viscoelastic properties inside living cells. Unlike bulk techniques, microrheology allows one to extract local material properties at microscopic length scales, thereby uncovering spatial heterogeneities that would otherwise remain hidden. A key advantage of microrheology lies in its extraordinary sensitivity. By exploiting the motion of probe particles, these methods act as transducers capable of detecting sub-nanometer displacements and pico-Newton forces with temporal resolutions down to the microsecond range. Because the probes are so small, their inertia becomes relevant only at frequencies approaching the megahertz, enabling accurate viscoelastic measurements across an exceptionally broad frequency window. In addition, the small strains inherent to microrheological techniques ensure that the material response can be studied within the linear viscoelastic regime, even in fragile samples.

This short course will combine theoretical foundations with practical applications, providing an integrated overview of both passive and active approaches. Participants will be introduced to the principles and experimental methods of multiple particle tracking, diffusing wave spectroscopy, optical tweezers, atomic force microscopy, and dynamic light scattering. The sessions will highlight the strengths and limitations of each technique, illustrate their application to synthetic and biological systems, and discuss experimental strategies and pitfalls. By the end of the course, attendees will have a comprehensive understanding of how microrheology can be applied to address fundamental questions and practical challenges across soft matter science, biomedical research, and industrial applications.

Proposed Programme (4 × 90 minutes)

Lecture 1 – Passive Microrheology I (Claude)

- Introduction to passive microrheology
- Diffusing Wave Spectroscopy: fundamentals and methodology
- Applications to surfactant systems, clay suspensions, and biopolymer solutions

Lecture 2 – Passive Microrheology II (Claude)

- Multiple Particle Tracking: fundamentals and data analysis
- Probing sample heterogeneity and local viscoelasticity
- Applications to biomaterials, 3D bioinks, and living matter

Lecture 3 – Hybrid Microrheology I (Manlio)

- Solving a Langevin equation for Optical Tweezers microrheology
- Active and passive microrheology with OT
- Case studies: complex fluids and living cells

Lecture 4 – Self-consistent Microrheology II (Manlio)

- Atomic Force Microscopy as a microrheological probe
- Dynamic Light Scattering (DLS) and microrheological extensions
- Hybrid and emerging techniques (e.g. OT–DLS combinations)
- Case studies: soft solids, gels, and living cells