ETH zürich

Department of Mechanical and Process Engineering

Focus: Energy, Flows and Processes

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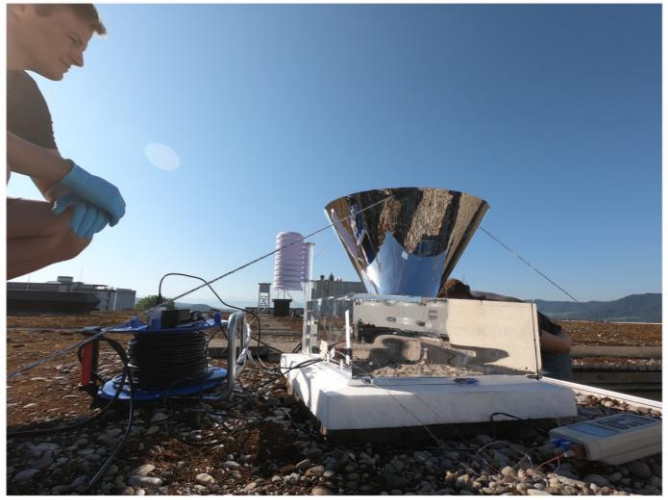
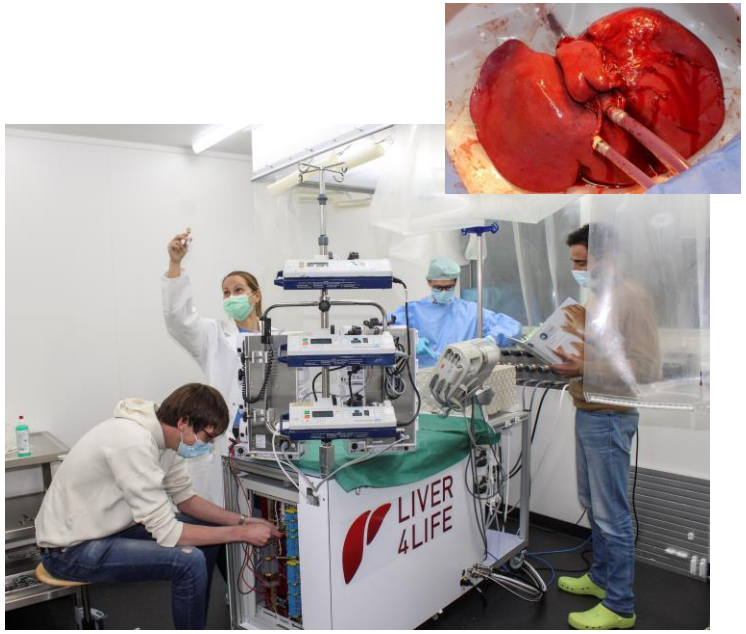
D MAVT

Area of Energy, Flows and Processes (EFP)

Contributes to the grand challenges of today's societies, including

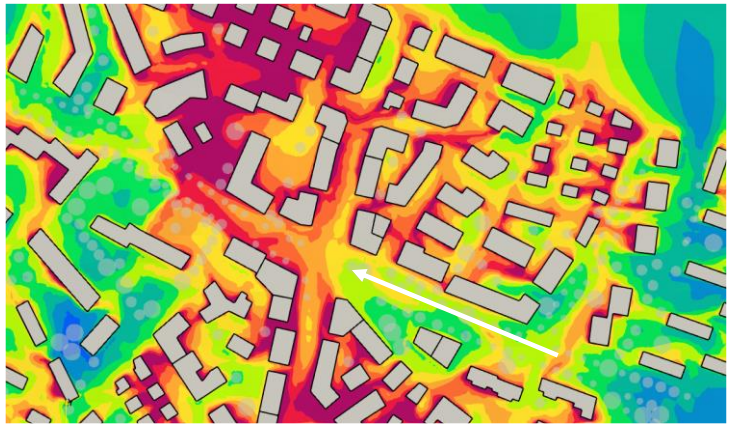


Supplying clean water



Ensuring healthy lives

Mitigating climate change



Enabling sustainable cities

Providing clean and reliable energy

and train our students to tackle such challenges through

- Teaching advanced fundamentals (computational fluid dynamics, heat & mass transfer, electrochemistry, *etc*.)
- Providing early hands-on experience with experimental techniques (flow diagnostics, material synthesis, *etc*.)
- Introducing modelling frameworks for sustainable energy systems
- Offering cutting-edge research projects for BSc theses.

The Energy, Flows and Processes Focus

Category	Course	Lecturer	
Core	Experimental methods for engineers	D. Norris *et al.*	
Core	Combustion and Reactive Processes in Energy and Materials Technology	N. Noiray and S. Pratsinis	
Core	Energy Systems and Power Engineering	R. Abhari and A. Steinfeld	
Core	Computational Methods for Flow, Heat and Mass Transfer Problems	D. Meyer-Massetti	2x
Elective	Mass Transfer	S. Pratsinis	
Elective	Turbulent Flow	P. Jenny	
Elective	Introduction into Process Engineering	C. Müller	
Elective	CO_2 Capture and Storage and the Industry of carbon-based resources	M. Mazzotti *et al*.	
Elective	Macromolecular Engineering: Networks and Gels	M. Tibbitt	
Elective	Introduction to Modelling and Optimization of Sustainable Energy Systems	A. Bardow and G. Sansavini	
Elective	Electrochemical Energy Systems	M. Lukatskaya	
Elective	Introduction to Photonics	R. Quidant	
Elective	Introduction to Quantum Mechanics for Engineers	D. Norris	2x

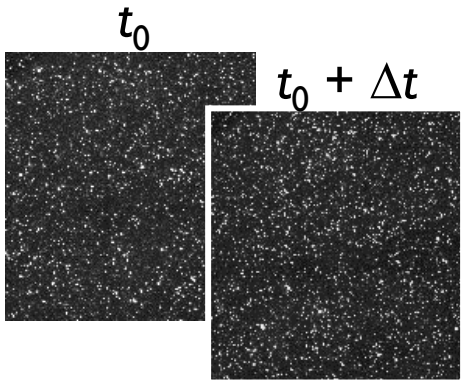
+ 1 course of the MAVT catalogue, i.e. 151-XXX

Experimental methods for engineers

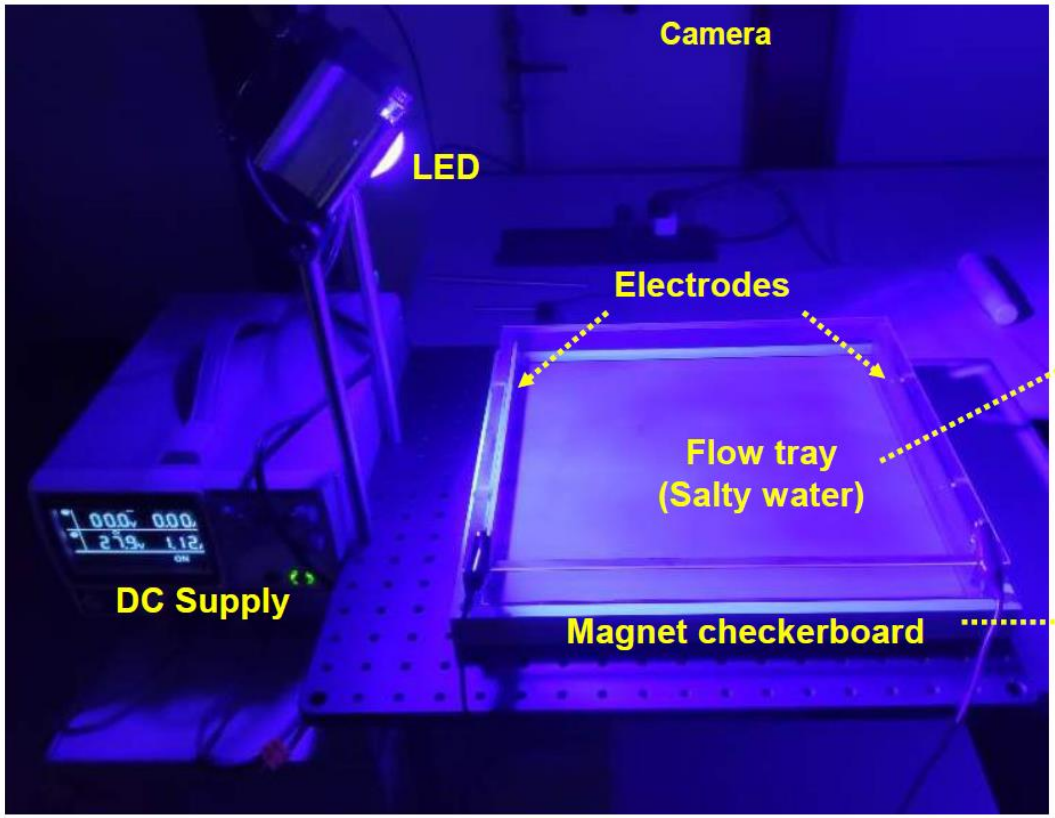
- Introduction to measurement technology: Data acquisition, data analysis, interfaces, etc.
- Introduction to sensors: Measurement of velocity, pressure, temperature, physical-chemical properties, flow fields or composition.
- Introduction to specific measurement methods and algorithms: LIF, UV-vis, LDV, PIV, Schlieren
- Practical examples through lab work.

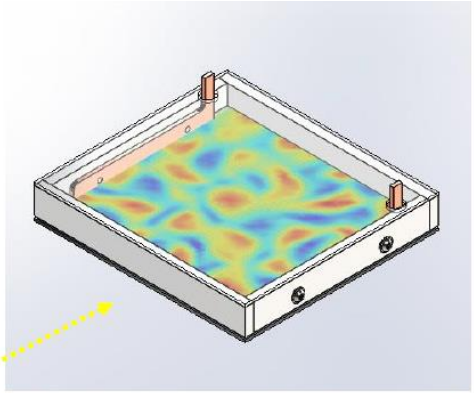
Particle Image Velocimetry (PIV) and Particle Tracking Velocimetry (PTV)

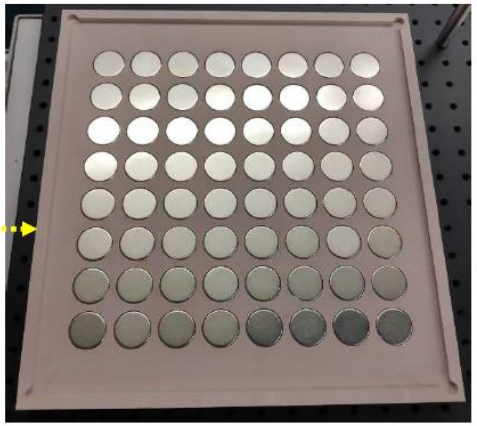
Based on series of images of tracer particles



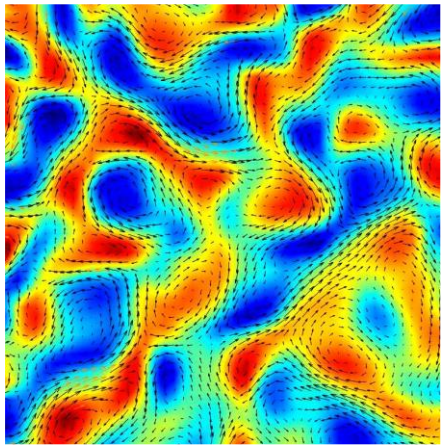
Applied to 2D turbulence: electromagnetically driven layer of conducting fluid



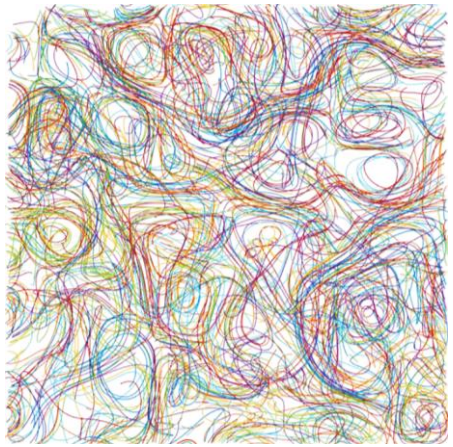




PIV: velocity fields



PTV: fluid trajectories



Eulerian vs Lagrangian description of same data set

Combustion and reactive processes in energy and materials technology

- Introduction to the basic equations in reactive flows, chemical thermodynamics and reaction kinetics.
- Two-phase flow/heterogeneous combustion.
- Turbulence and turbulent flames.
- Pollutant formation chemistry (nitrogen oxides, nanoparticles, etc.)
- Flame synthesis of materials: pigments, fillers and optical fibres.

Energy Systems and Power Engineering

- Introduction to sustainable energy system and environmental impact of energy conversion.
- Electric power distribution system.
- Renewable energy and power.
- Cost of electricity.
- Conventional power plants and their cycles.
- Hydrogen and fuel cells.

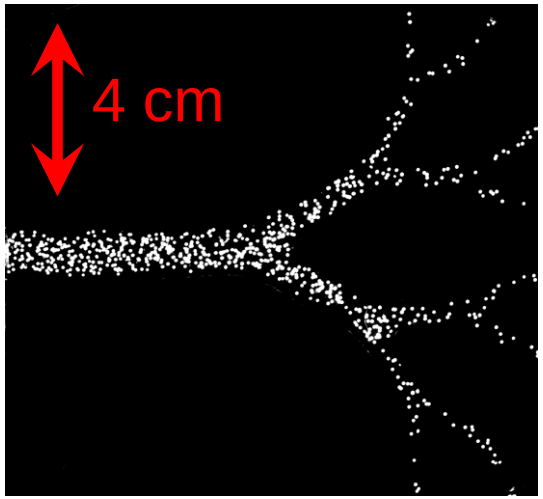
Computational methods for flow, heat and mass transfer problems

- Basic equations, initial and boundary conditions.
- Numerical approaches for discretization: Finite-differences and finite-volume approaches, finite element method.
- Solution of fundamental classes of equations: heat conduction/diffusion equations, Poisson equation, advection equation and advection-diffusion equation.
- Stability analysis, criteria for convergence, error estimation.

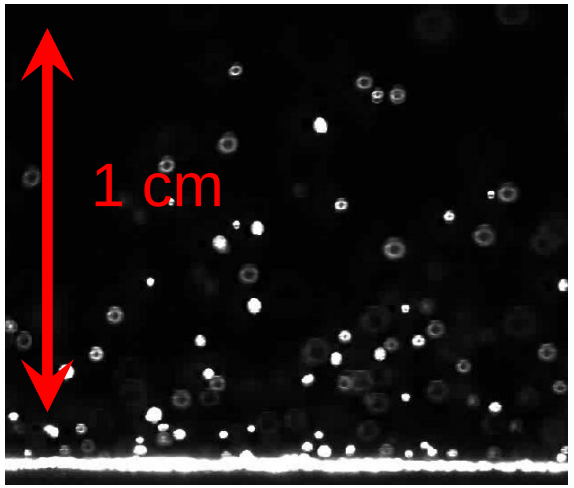
Experimental Fluid Dynamics

Filippo Coletti

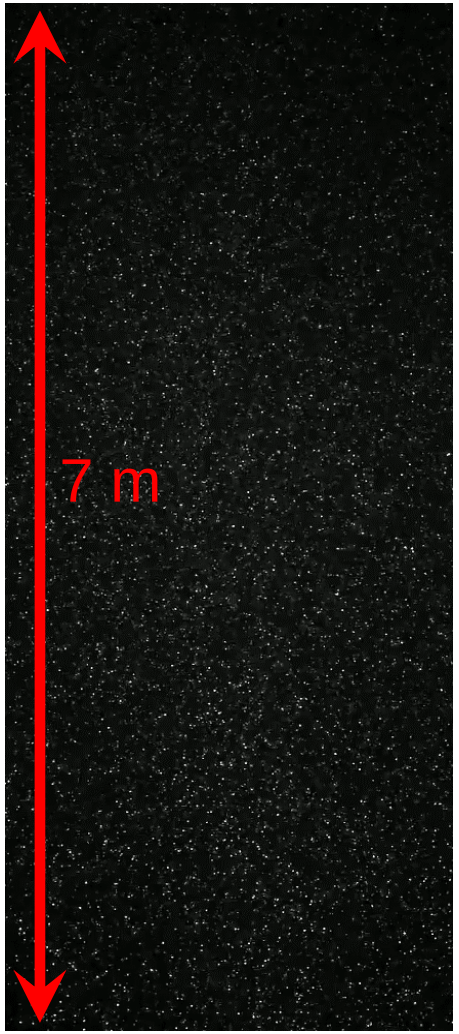
Research on multi-scale and multi-phase interactions in complex and turbulent flows



Particle transport in vessels



Sand saltation in the wind



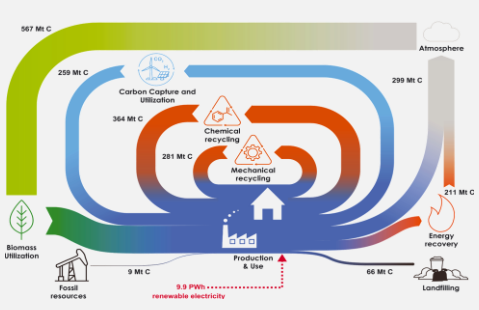
Snowflakes falling in the atmosphere

Applications: Targeted drug-delivery, solar energy receivers, micro-plastics in water, weather forecast

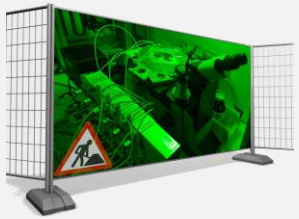
Energy and Process Systems Engineering

André Bardow

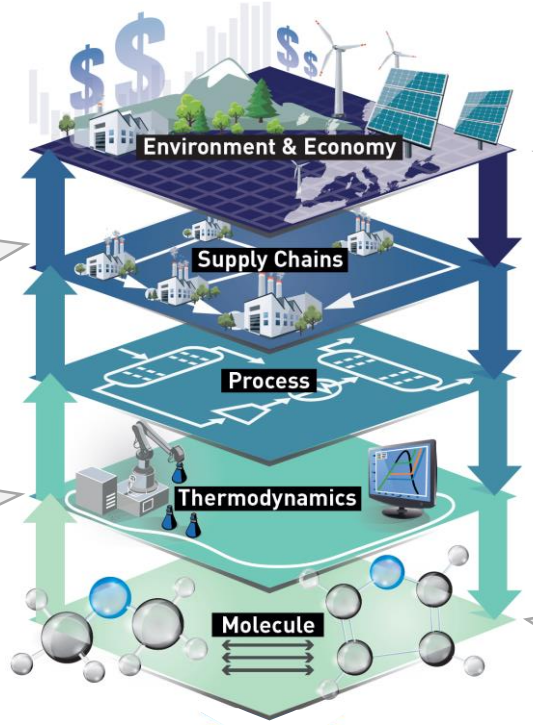
Sustainable energy and chemical production systems



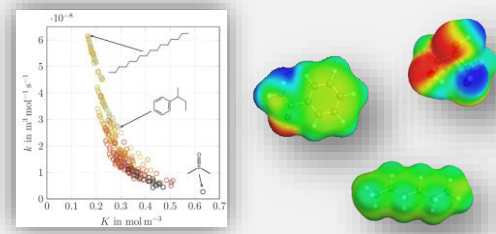
Net-zero plastics industry



Automated thermodynamic characterization



Carbon-neutral energy system



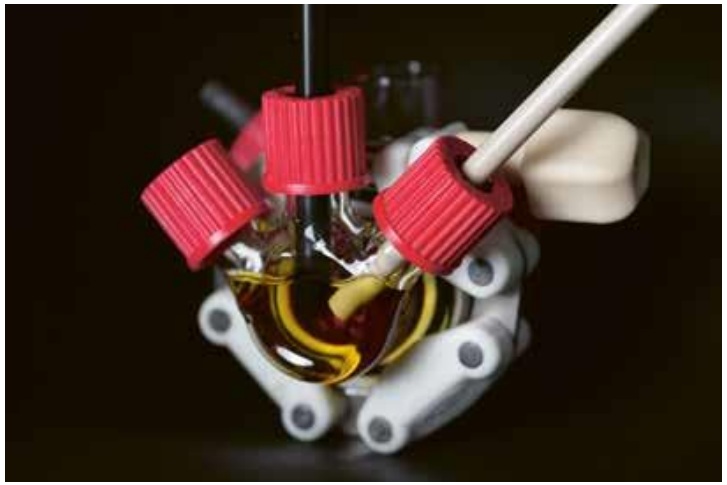
Computer-aided molecular design

Applications: Power-to-X & sector coupling, sustainable carbon, and carbon capture, utilization & storage

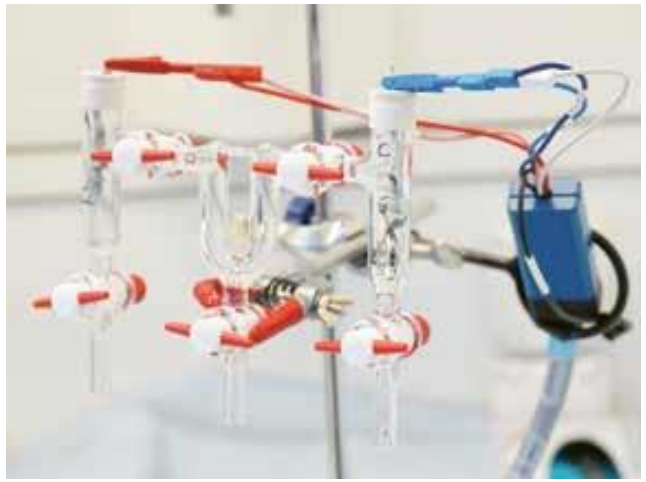
Electrochemical Energy Systems

Maria Lukatskaya

Research on electrolytes and interfaces, materials, electrocatalysis, supercapacitors, green storage



Electrochemical energy conversion



Transport properties of electrolytes

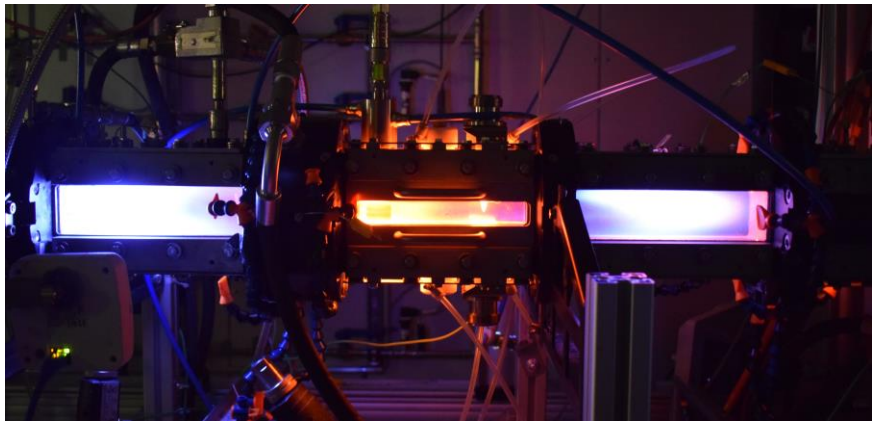
Battery research

Applications: New battery materials, electrocatalysts and electrolytes that can deliver improved performance (i.e. charging times, energy density, activity and stability), cost, efficiency and safety.

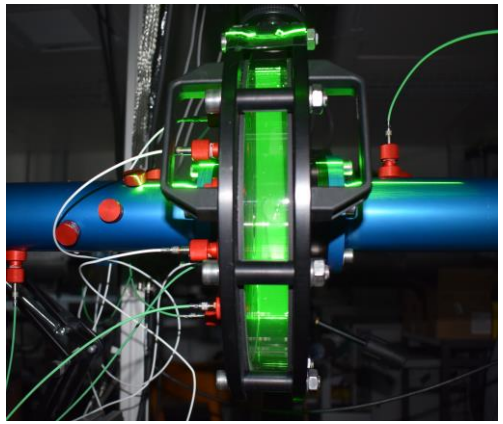
Combustion and Acoustics for Power & Propulsion Systems

Nicolas Noiray

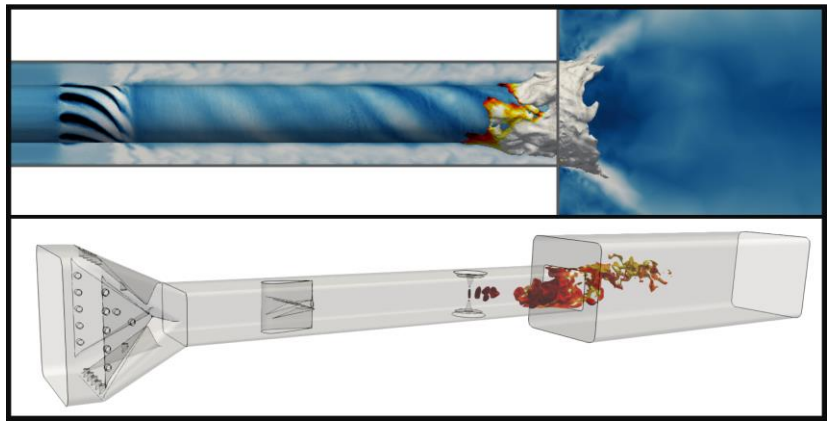
Research on Combustion, Acoustics and Fluid Mechanics



H_2 combustion experiments



Aeroacoustics



Computational fluid dynamics

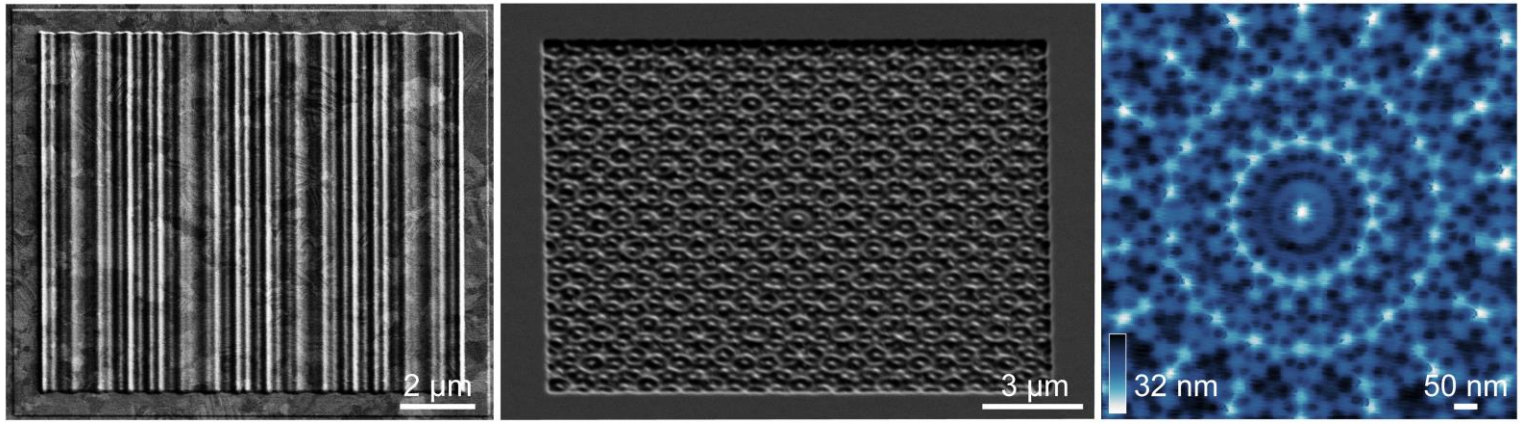
Applications: Gas turbines for electricity production from sustainable fuels such as H_2, Propulsion systems for aeronautic and aerospace applications, …

Optical Materials Engineering

David Norris

Research on optical materials, optical phenomena, and devices

Colloidal quantum dots



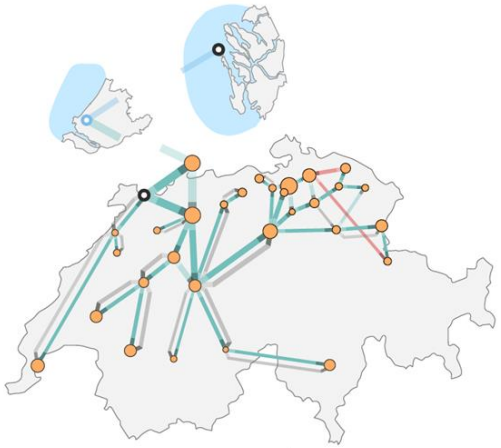
Plasmonic, photonic, and electronic surfaces (Fourier structures)

Applications: Displays, light-emitting devices, lasers, 2D electronics, photonic integrated circuits, ...

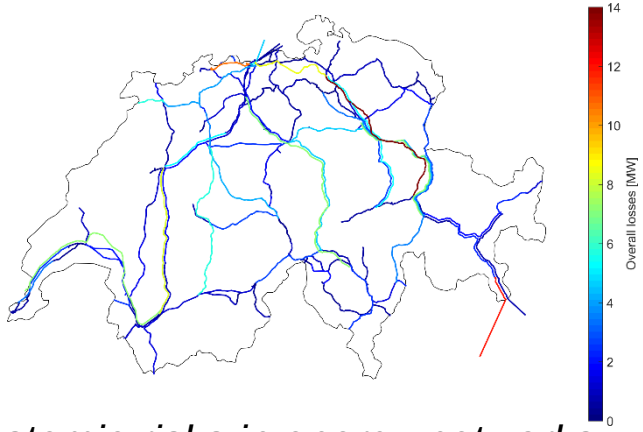
Reliability and Risk Engineering

Giovanni Sansavini

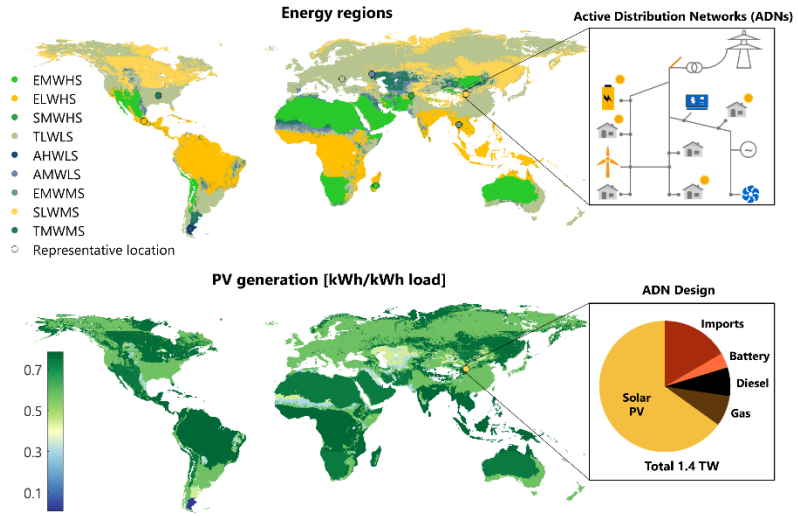
Research on transition to resilient, fair and sustainable energy and critical infrastructure systems



Chemical supply chains



Systemic risks in energy networks



Global energy infrastructure

Applications: Distributed multi-energy systems, cascading failures in complex networks, sector coupling and interdependencies in energy supply, design and operations of CO_2 and H_2 value chains, …

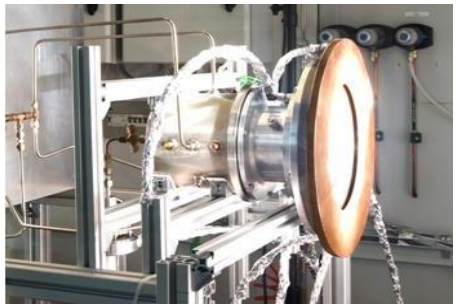
Renewable Energy Carries

Aldo Steinfeld

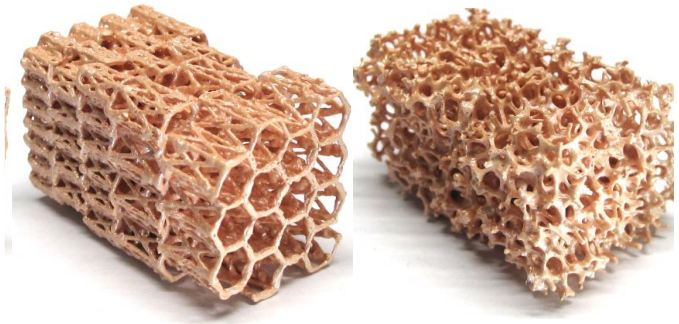
Heat/mass transport phenomena at high temperatures

Functional materials for thermal energy conversion and storage

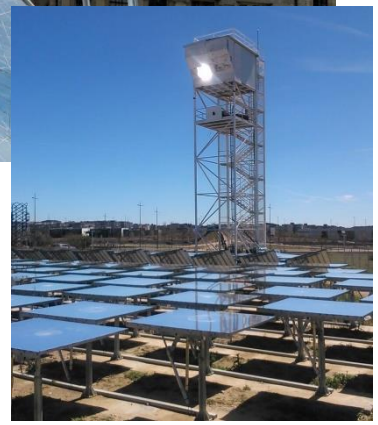
Thermochemical reactor engineering for multi-phase reacting flows



Solar reactor for splitting H_2O and CO_2



3D-printed and reticulated redox ceramic structures



Fuels from sunlight and air

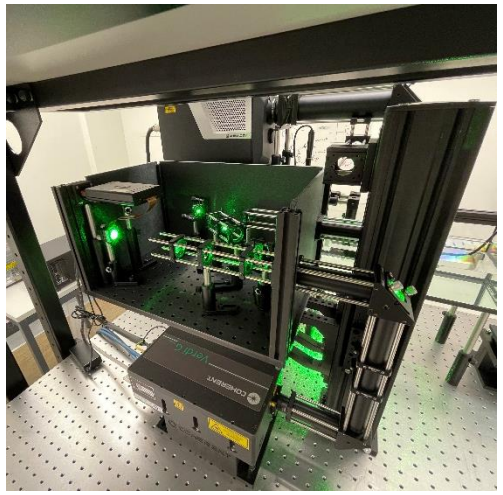
Technology R&D at:
- *high solar fluxes (>5000 suns)*
- *high temperatures (>1000°C)*

Applications: Concentrated solar power & fuels, CO_2 direct air capture and utilization, Solar processing of carbon-neutral chemicals (metals, cement, ammonia)

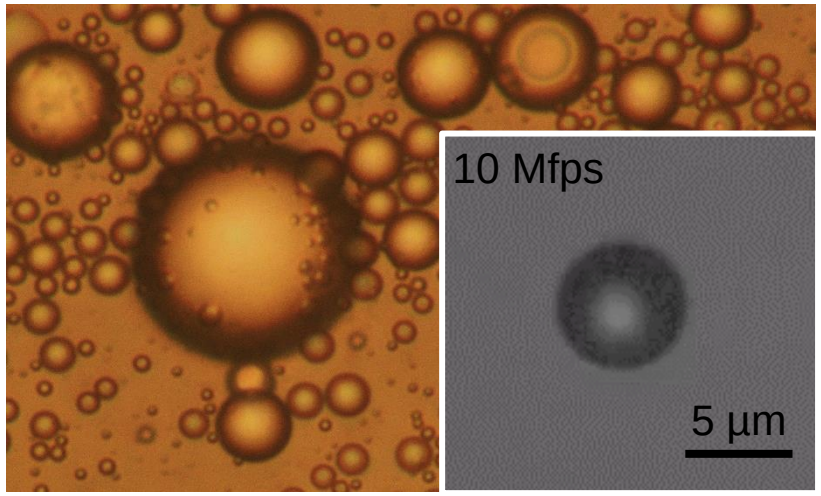
Multiphase Fluid Dynamics

Outi Supponen

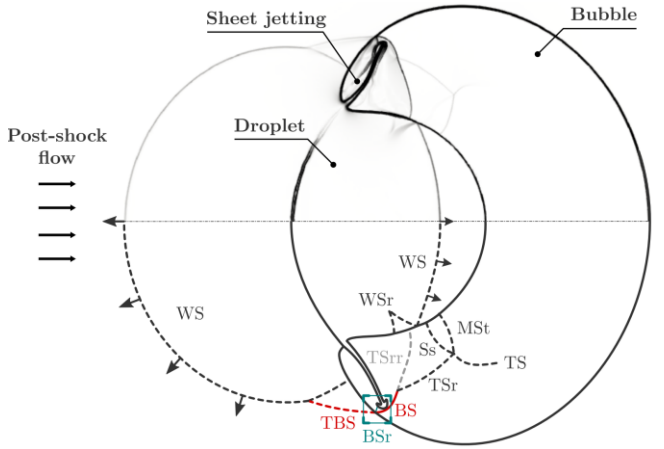
Research on experimental fluid dynamics, bubbles, droplets, acoustics and microfluidics



Ultra-high-speed videomicroscopy and optical micromanipulation



Ultrasound contrast agent microbubbles and droplets



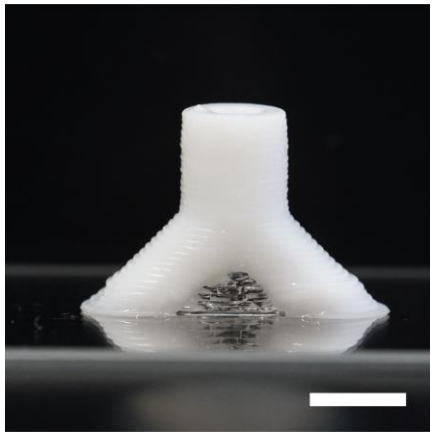
Experimental and numerical investigations on bubble dynamics

Applications: Medical imaging and therapy, bubble-based, metamaterials, chemical processing, microfluidics

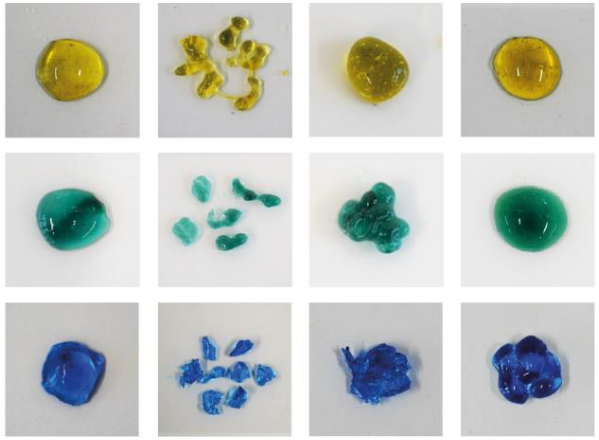
Macromolecular Engineering

Mark Tibbitt

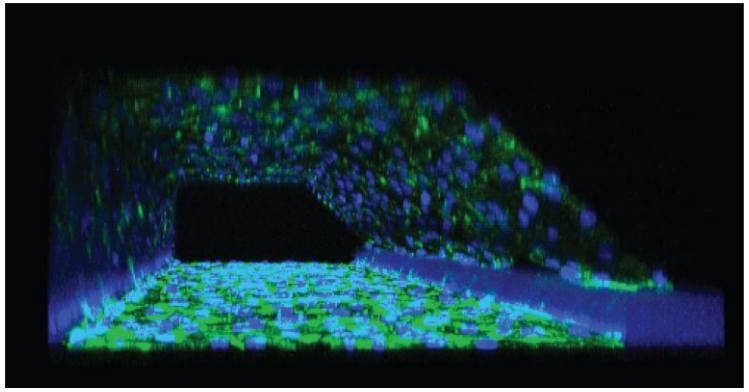
Research on soft matter and biomaterials



3D bioprinting



Dynamic covalent networks



Microvasculature-on-a-chip

Applications: Healthcare, regenerative medicine, drug delivery, organs-on-chip, sustainable materials