

## SYSC 1: The Sustainability Challenge: A Decade of Transformation

Time: Monday 15:00–17:45

Location: HSZ/AUDI

**Invited Talk** SYSC 1.1 Mon 15:00 HSZ/AUDI  
**Open-Endedness and Community-Based Approaches to Sustainability Challenges** — •HIROKI SAYAMA — Binghamton University, State University of New York, Binghamton, NY, USA — Waseda University, Tokyo, Japan

The sustainability of our natural and social environments is of utmost importance in today's complex world. Achieving this goal is challenging because of: the complexity of interconnected networks involving numerous variables, factors, and stakeholders; the uncertainty and unpredictability in the dynamics of these components and their interactions; the possibility of unexpected outcomes resulting from well-planned solutions; and the fundamental lack of cooperative incentives for stakeholders to participate in actions that are collectively beneficial yet individually detrimental. To address these difficult sustainability challenges, one can benefit from insights into complex systems, especially the open-endedness of complex dynamical/evolutionary systems and the active involvement of community members in participatory solution development. In this talk, I will provide a birds-eye view of the recent open-endedness literature being developed in complexity science, artificial life, and AI, and discuss its relevance to sustainability issues. I will also report on a concrete example of community-based approaches to sustainability implemented in the Greater Binghamton area (called the "Binghamton Two Degrees" project). These approaches are becoming increasingly relevant in our sustainability efforts, as we now face irreversible environmental changes arising in a world that may have already passed the critical transition point.

**Invited Talk** SYSC 1.2 Mon 15:30 HSZ/AUDI  
**Education as a Social Tipping Element: Evidence from Climate and Physics Education Research** — •THOMAS SCHUBATZKY — University of Innsbruck, Innsbruck, Austria

The concept of social tipping elements draws attention to societal leverage points that may accelerate transitions towards sustainability. Education is frequently named as one of these leverage points. In this talk, I outline key findings from recent meta-analyses and review studies in climate and physics education research and discuss the conditions under which educational processes may exert transformative effects. The evidence thereby consistently shows substantial gains in climate-related knowledge, while effects on attitudes and behavioural outcomes are smaller but reliably detectable. The pronounced heterogeneity across studies, however, indicates that the underlying mechanisms of effective climate education are still insufficiently understood. The talk addresses this challenge by drawing on selected empirical studies that illustrate how educational interventions can initiate reinforcing feedbacks at both the individual and collective level. These studies are intended to highlight concrete pathways through which education may operate as a social tipping element, and how micro-level learning processes could scale up to support broader societal transformation.

**Invited Talk** SYSC 1.3 Mon 16:00 HSZ/AUDI  
**Mechanistic and Material Perspectives on Enzymatic Hydrolysis of Semicrystalline Polyesters** — •BIRTE HÖCKER — Biochemie, Universität Bayreuth, Germany

Enzymatic degradation of polyethylene terephthalate (PET) provides a sustainable route for polyester recycling, yet efficiency remains limited by both enzyme diversity and substrate properties. To address this, we developed a tunable degradation platform incorporating realistic substrates and adaptable to various polyesters, enabling parallelized

purification and high-throughput characterization of novel enzymes and engineered variants. Using this system, we identified halophilic PETases from the marine *Halopseudomonas* lineage. High-resolution crystallography of one candidate revealed a unique active-site architecture lacking the canonical  $\pi$ -stacking clamp and exhibiting altered loop conformations, prompting an extension of the PETase classification to include type III enzymes. These enzymes demonstrated remarkable salt tolerance and improved PET hydrolysis at elevated temperatures. Complementary studies on polybutylene terephthalate (PBT) highlight the critical role of semicrystalline morphology: reducing crystallinity and optimizing incubation near the glass transition significantly enhance hydrolysis. By expanding the structural and sequence space of PET-degrading enzymes, combined with material-specific insights, we aim to establish a foundation for efficient enzymatic recycling of semicrystalline polyesters and support the development of next-generation biocatalysts for sustainable plastic management.

### 15 min break

**Invited Talk** SYSC 1.4 Mon 16:45 HSZ/AUDI  
**Decarbonization Options for Industry** — •UWE RIEDEL — DLR Institut für CO<sub>2</sub>-arme Industrieprozesse, 03046 Cottbus, Deutschland  
 Industrial decarbonization is pivotal to achieving emission targets. In 2024, CO<sub>2</sub>-emissions from the industrial sector amounted to approximately 153 million tons, accounting for around 25% of Germany's total CO<sub>2</sub>-emissions.

However, decarbonizing this sector is challenging due to the wide variety of processes involved. In some cases, electrification is a viable solution, but often, sector-specific approaches are necessary. The presentation will show examples from various sectors and explain the options available for different process temperatures.

**Invited Talk** SYSC 1.5 Mon 17:15 HSZ/AUDI  
**Impacts of Cosmic Dust and Space Debris in the Terrestrial Atmosphere** — •JOHN PLANE — School of Chemistry, University of Leeds, UK

Cosmic dust particles are produced from sublimating comets and collisions between asteroids. Because the particles enter the atmosphere at hypersonic velocities, collisional heating with air molecules leads to vaporization of their metallic constituents. The injection of these elements causes a wide variety of atmospheric phenomena: global layers of metal atoms between 80 and 105 km; airglow emissions; metallic ions (sporadic E layers) which affect radio communications; and meteoric smoke particles which enable the nucleation of mesospheric ice clouds and the freezing of polar stratospheric clouds. Certain metal atoms can be observed by ground-based lidar and from satellites, providing excellent tracers of dynamics and chemistry at the edge of space.

The global mass input rate of cosmic dust to the atmosphere is estimated to be around 27 tonnes per day. This estimate was obtained using an astronomical dust model to provide the size and velocity distributions of dust in the inner solar system, combined with a chemical ablation model to determine the rates of metal injection and deposition of cosmic spherules in the polar ice-caps. The re-entry of spacecraft from low Earth orbit currently produces influxes of metals such as aluminium and lithium which already exceed natural background levels. The atmospheric implications of the expected significant increase in these anthropogenic fluxes during the next decade will be discussed.