Symposium Tipping Points in Social and Climate Systems (SYTP)

jointly organised by
the Physics of Socio-economic Systems Division (SOE),
the Dynamics and Statistical Physics Division (DY),
the Environmental Physics Division (UP),
the Thin Films Division (DS), and
the Working Group "Young DPG" (AKjDPG).

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The concept of tipping points has become central to understanding both climate dynamics and social transformations. This symposium brings together physicists and interdisciplinary researchers to explore the mechanisms underpinning tipping behavior in complex systems. Topics include nonlinear dynamics of the Earth system, early warning signals of climate tipping points, and the emergence of social tipping cascades in response to policy, technology, and behavioral shifts.

Overview of Invited Talks and Sessions

(Lecture hall HSZ/AUDI)

Invited Talks

SYTP 1.1	Thu	15:00–15:30	HSZ/AUDI	**Social Tipping in Heterogeneous and Polarized Populations** — •Sara Constantino, Sonke Ehret, Elke Weber, Sonja Vogt, Charles Efferson
SYTP 1.2	Thu	15:30–16:00	HSZ/AUDI	**Tipping points and regime shifts in coupled social-climate systems** — •Chris Bauch
SYTP 1.3	Thu	16:00–16:30	HSZ/AUDI	**How to tune Earth system models toward tipping?** — •Sebastian Bathiany, Niklas Boers
SYTP 1.4	Thu	16:45–17:15	HSZ/AUDI	**Algorithmic amplification and contextual sensitivity in political information exposure** — Iris Damião, Ana Vranic, Paulo Almeida, Lília Perfeito, •Joana Gonçalves de Sá
SYTP 1.5	Thu	17:15–17:45	HSZ/AUDI	**The complex interplay between democracy and platform power** — •Philipp Lorenz-Spreen

Sessions

SYTP 1.1–1.5	Thu	15:00–17:45	HSZ/AUDI	**Tipping Points in Social and Climate Systems**
SOE 16.1–16.4	Thu	11:30–12:45	GÖR/0226	**Tipping Points in Social and Climate Systems (accompanying session for SYTP)**

SYTP 1: Tipping Points in Social and Climate Systems

Time: Thursday 15:00–17:45   Location: HSZ/AUDI

Invited Talk   SYTP 1.1   Thu 15:00   HSZ/AUDI
Social Tipping in Heterogeneous and Polarized Populations
— •Sara Constantino[1], Sonke Ehret[2], Elke Weber[3], Sonja Vogt[2], and Charles Efferson[2] — [1]Stanford University, Stanford, USA — [2]University of Lausanne — [3]Princeton University

Leveraging social norms to create widespread social change through circumscribed interventions has been hailed as an effective mechanism for addressing climate change. Lab experiments find that a small fraction of a population - a committed minority - can tip a population to an alternative stable state. However, the feasibility of social tipping interventions to incite widespread change depend on specific conditions. In two online experiments, we test (1) the role of group identities in facilitating and interrupting the emergence of social norms, and (2) how heterogeneous preferences impact whether an intervention is effective or not. In the first study, we ran an online experiment in which participants faced consistent incentives to coordinate their choices. We found that while the control groups developed norms slowly before intervention, they transitioned to new norms rapidly after intervention. In contrast, the identity groups developed norms rapidly before intervention but persisted in a state of costly disagreement after an intervention. In a second study, we ran a group experiment where we tested the effects of prior preferences and the magnitude and targeting of tipping interventions. Our results show that pre-intervention heterogeneity significantly moderated the effects of tipping interventions. These findings suggest social tipping success depends on mundane features of the environment.

Invited Talk   SYTP 1.2   Thu 15:30   HSZ/AUDI
Tipping points and regime shifts in coupled social-climate systems — •Chris Bauch — Department of Applied Mathematics, University of Waterloo, Canada

Coupled social-climate interactions are important, yet the modelling of such systems is in its infancy, including the study of their tipping points. In this talk, I will touch briefly on two coupled social-climate models*a simpler model intended to study potential interactions between climate and social tipping points, and a more realistic model with regional structure that is parametrised with geophysical, economic, demographic and social data. Among other findings, I will highlight some unexpected predictions that emerge from the nonlinear interactions in the models. I will also touch upon data-driven dynamical systems approaches to predicting tipping points in climate and social-climate systems.

Invited Talk   SYTP 1.3   Thu 16:00   HSZ/AUDI
How to tune Earth system models toward tipping? — •Sebastian Bathiany[1,2] and Niklas Boers[1,2] — [1]Technical University of Munich — [2]Potsdam Institute for Climate Impact Research

Models of complex dynamical systems like the Earth's climate often involve large numbers of uncertain parameters. Comprehensive exploration of the parameter space is typically prohibitive due to excessive computational costs. Systematic gradient-based parameter optimization is not feasible because such models are typically not differentiable. This is especially problematic in cases where the models describe highly nonlinear and possibly abrupt dynamics, where sensitivity to parameter changes is high. Components of Earth's climate system, such as the North Atlantic Overturning Circulation or the polar ice sheets, are at risk of undergoing critical transitions in response to anthropogenic climate change. Concerns have been raised that these Earth system components are too stable in state-of-the-art models. In my presentation, we will see examples how new scenario simulations allow studying

the possibility and the consequences of tipping events in Earth system models. Also, we will discuss a method for efficient, systematic, and objective calibration of dynamical complex system models, targeted at adjusting system stability. Given a number of physical or observational constraints, the method can efficiently adjust stability biases in a range of complex system models and help reveal potentially hidden instabilities, with important implications for Earth system modelling.

15 min. break

Invited Talk   SYTP 1.4   Thu 16:45   HSZ/AUDI
Algorithmic amplification and contextual sensitivity in political information exposure — Iris Damião, Ana Vranic, Paulo Almeida, Lília Perfeito, and •Joana Gonçalves de Sá — LIP, Lisbon, Portugal

Understanding criticality and tipping points is key to analyzing how small changes can cascade into large-scale effects. In information ecosystems, these dynamics emerge in both social media and algorithmically mediated platforms, where recommendation systems interact with user behavior to produce disproportionate societal impacts.

Misinformation on platforms like Twitter (X) is often assumed to spread faster than the truth. Yet, empirical evidence varies. Analyzing three large datasets -Vosoughi News, Global Claims, and Truth Seeker- we find that cascade size distributions are very dependent on sampling choices and this sensitivity can lead to opposite results when studying information diffusion.

Beyond social media, search engines (SEs) and large language models (LLMs) increasingly shape access to information. Using a privacy-preserving bot system, we conducted synchronized searches prior to the 2024 European Parliament. Results varied by location and query type; however, SEs and LLMs consistently emphasized right-leaning entities, revealing systematic algorithmic bias.

Together, these findings illustrate that algorithmically driven platforms can reflect and amplify political biases, creating fragmented informational realities.

Invited Talk   SYTP 1.5   Thu 17:15   HSZ/AUDI
The complex interplay between democracy and platform power — •Philipp Lorenz-Spreen — Center Synergy of Systems, TU Dresden, Germany

Information and communication technology has undergone dramatic developments over the last two decades. Increasing interconnectedness has led to more self-organized public debates, platforms and their algorithms have gained new power over discourse, and generative AI has made content fabrication easier than ever. But it has also given research new tools to quantify precisely these systemic changes. Detailed data from social media allows us to measure and model their network structures and dynamics. Against this background, we ask: What is really changing, what does science know about the connection between the crises of democracy and the worldwide use of digital and social media? A number of political behaviors appear to be influenced by the use of digital media, such as increasing polarization or declining trust in institutions. Our findings show that while there is agreement in the literature on some of the relationships, these vary across the world and, above all, the underlying mechanisms by which these dimensions are linked are still unknown. A better understanding of these systems is critical for civil society in democracies worldwide, and I will conclude with a methodological outlook on how we are currently trying to explore these missing puzzle pieces.