SOE 16: Social Systems, Opinion and Group Dynamics

Time: Wednesday 15:30–18:00 Location: MA 001

SOE 16.1 Wed 15:30 MA 001

Modelling opinion dynamics under the impact of influencer and media strategies — •Natasa Djurdjevac Conrad[1], Christof Schütte[1,2], Luzie Helfmann[1], and Philipp Lorenz-Spreen[3] — [1]Zuse Institute Berlin, Berlin, Germany — [2]Freie Universität Berlin, Berlin, Germany — [3]Max Planck Institute for Human Development, Berlin, Germany

In this talk, we will propose a novel agent-based model (ABM) that aims to model how individuals (agents) change their opinions under the impact of media and influencers. We will study the rich behavior of this ABM in different regimes and explore how different opinion formations can emerge, e.g. consensus and fragmentation. This framework allows for mean-field approximations by partial differential equations, which reproduce the dynamics and allow for efficient large-scale simulations when the number of individuals is large. Based on the mean-field model, we will show how strategies of influencers can impact the overall opinion distribution and that optimal control strategies allow other influencers (or media) to counteract such attempts and prevent further fragmentation of the opinion landscape.

SOE 16.2 Wed 15:45 MA 001

The dynamics of public and private opinions as interacting complex contagions — •Barbara Kaminska[1], Arkadiusz Jedrzejewski[2], and Katarzyna Sznajd-Weron[1] — [1]Wrocław University of Science and Technology — [2]CY Cergy Paris Université

Human decision-making and the process of opinion formation are inherently complex. This process involves two distinct levels: the external, where opinions are openly expressed, and the internal, where beliefs are privately held. These levels are shaped by a dynamic interplay between independent choices, social interactions as well as their mutual impact, akin to the concept of interacting complex contagions. Previous research, grounded in agent-based modeling, has explored this interplay primarily by considering how publicly expressed views depend on private beliefs. In this work, we extend this investigation to consider mutual interactions between opinions at the public and private levels. The main objective of this study is to assess the impact of self-confirmation and the desire to reduce cognitive dissonance, the misalignment between internal and external opinions. This also means exclusion of self-anticonformity, a factor present in our previous work. Through Monte Carlo simulations and analytical analysis, we demonstrate that a model without self-anticonformity supports the emergence of social hysteresis, a form of collective memory closely linked to delays in responding to changing external conditions. The results obtained in this work show also that self-anticonformity can foster agreement among agents, aligning with similar results from various other models.

SOE 16.3 Wed 16:00 MA 001

Accelerated consensus and stable dissent in projected argument-based opinion dynamics — •Sven Banisch and Joris Wessels — Karlsruhe Institute for Technology

This contribution reports on a first exercise to project an opinion model with psychologic depth onto continuous opinion dynamics. In the argument model, agents exchange arguments, or beliefs, and form their opinion based on evaluations of them. In continuous opinion dynamics, agents have only opinions that adapt in interaction with other opinions. Here we study which dynamics are implied by explicit argument exchange with confirmation bias on the space of continuous models. We were surprised by this exercise, because some things we had not anticipated emerged. While it was expected that consensus forms quickly in the projected, but not in the explicit model, we did not expect that the meta-stable state of polarization would stabilize after projection. Qualifying model outcomes by their convergence properties may capture differences between models more than their phenomenological similarities. With psychological depth, the transient becomes relevant. We discuss implications for coupled models, in which opinion dynamics is included in a disease or climate model, and where reducing model complexity is highly desirable for computational reasons as well as for a systematic understanding of different model classes.

SOE 16.4 Wed 16:15 MA 001

Instability Cycles in an Adaptive Network Model of Society — •Alexander Jochim and Stefan Bornholdt — Institute for Theoretical Physics, University of Bremen

Political instability and violence, enduring phenomena throughout history, pose complex challenges for societies. Recent research has uncovered compelling quantitative evidence of common patterns across various societies in history. Proxy variables for average well being and societal elites have been utilized to calculate political stress [1]. However, the transition from microscopic interactions to macroscopic behavior remains poorly understood, with only qualitative theories as a guidance.

We here study an agent based toy model of society, exhibiting cycles of instability and inequality as emergent patterns resulting from simple micro interactions. This may improve our understanding of political instability by bridging the gap between qualitative theories and quantitative agent based modeling.

[1] P. Turchin, Ages of discord (Beresta Books, 2016).

SOE 16.5 Wed 16:30 MA 001

Rigorous Agent-Based Modeling is critical: Modeling the diffusion of green products and practices — •Angelika Abramiuk-Szurlej, Mikołaj Szurlej, and Katarzyna Sznajd-Weron — Wrocław University of Science and Technology, 50-370 Wrocław, Poland

Agent-based modeling (ABM) is gaining popularity in the field of managing pro-environmental behavior change. In the field of ecology, it is a well-established and rigorous scientific method. However, within social sciences, it is often criticized for its lack of rigor. We demonstrate how best practices from ABM in ecology can be applied to the study of pro-environmental social change. We argue that the two stages of ABM, namely description and verification, are fundamental for establishing ABM as a rigorous research method. Therefore, we provide a practical illustration of how to effectively execute these stages using an example of a model introduced in 2016 to study the diffusion of green products and practices. We describe the model using the ODD (Overview, Design concepts, Details) protocol. Furthermore, we present two different approaches to model analysis borrowed from the theory of complex systems to ensure rigorous model verification. We also clarify the circumstances under which the agent-based model can be reduced to an analytical model and when such reduction is not feasible. Finally, we present new results for the model that have not been previously reported. Specifically, we demonstrate that the model effectively replicates patterns observed in the real diffusion of innovations, including the S-shaped curve and the concept of critical mass.

15 min. break

SOE 16.6 Wed 17:00 MA 001

Poll-delayed immitation in the noisy voter model — •Aleksejus Kononovicius[1], Rokas Astrauskas[2], Marijus Radavicius[2], and Feliksas Ivanauskas[2] — [1]Institute of Theoretical Physics and Astronomy, Vilnius University, Vilnius, Lithuania — [2]Faculty of Mathematics and Informatics, Vilnius University, Vilnius, Lithuania

Noisy voter model is driven by two mechanisms: exploration and peer pressure. Exploration corresponds to the independent noisy flipping of individual agent states. Peer pressure on the other hand encourages the agents to copy the state of their peers (i.e., imitate their behavior). Here we consider an extension of the noisy voter model in which the peer pressure is exerted via the polling mechanism. As typical in the real world polling information is at least somewhat delayed. We show that when delay is comparatively short, the poll-delayed model is statistically identical to the original model. As delays become longer, oscillatory behavior emerges, but the model still converges to a steady state distribution. The effect of polling mechanism is explored both analytically and numerically.

SOE 16.7 Wed 17:15 MA 001

Individual bias and fluctuations in collective decision making: From algorithms to Hamiltonians. — Petro Sarkanych[1], Yunus Sevinchan[2,3], Mariana Krasnytska[1], Luis Alberto Gomez-Nava[4], Abi Tenenbaum[5], Yurij Holovatch[1], and •Pawel Romanczuk[2,3] — [1]Institute for Condensed Matter Physics of the National Academy of Sciences of Ukraine, Lviv, Ukraine — [2]Dep. of Biol-

ogy, Humboldt Universität zu Berlin, Germany — [3]Excellence cluster "Science of Intelligence", Berlin, Germany — [4]Laboratoire Matière et Systèmes Complexes, Université Paris Cité, France — [5]Yale University, USA

We investigate a spin model proposed by [Hartnett et al., Phys. Rev. Lett. 116 038701 (2016)] for understanding collective decision-making in higher organisms. The model uses opinion and bias variables to represent agents' states, interpreting decision-making as an approach to equilibrium in a nonlinear voter model with social pressure. We extend the model by introducing noise, and push the statistical physics interpretation further by deriving the Hamiltonian and calculating the partition function, revealing two possible Hamiltonian formulations based on different considerations on social interactions. Exact solutions for thermodynamics on complete graphs are obtained and validated through simulations. Further, we explore the impact of system size and initial conditions on collective decision-making. We also analyze the spin model on Erdos-Renyi random graphs, discussing susceptibility, critical points, and the network's response to a periodic external field.

SOE 16.8 Wed 17:30 MA 001

Consensus, Polarization and Hysteresis in the Three-State Noisy q-Voter Model with Bounded Confidence — •Maciej Doniec, Arkadiusz Lipiecki, and Katarzyna Sznajd-Weron — Wroclaw University of Science and Technology

In this work, we address the question of the role of influence group size on the emergence of various collective social phenomena, such as consensus, polarization, and social hysteresis. To answer this question, we study the three-state noisy q-voter model with bounded confidence, in which agents can be in one of three states: two extremes (leftist and rightist) and centrist. We study the model on a complete graph within the mean-field approach and show that depending on the size q of the influence group, saddle-node bifurcation cascades of different length appear and different collective phenomena are possible. In particular, for all values of $q > 1$ social hysteresis is observed. Furthermore, for small values of $q \in (1, 4)$ disagreement, polarization and domination of centrists (a consensus understood as the general agreement, not unanimity) can be achieved, but not domination of extremists. The latter is possible only for larger groups of influence. Finally, by comparing our model to others, we discuss how a small change in rules at the microscopic level can dramatically change the macroscopic behavior of the model.

SOE 16.9 Wed 17:45 MA 001

Homophily-Based Social Group Formation in a Spin Glass Self-Assembly Framework — •Jan Korbel — Section for the Science of Complex Systems, CeMSIIS, Medical University of Vienna, Spitalgasse 23, A-1090, Vienna, Austria — Complexity Science Hub Vienna, Josefstädterstrasse 39, A-1080, Vienna, Austria

Homophily, the tendency of humans to attract each other when sharing similar features, traits, or opinions, has been identified as one of the main driving forces behind the formation of structured societies. Here, we ask to what extent homophily can explain the formation of social groups, particularly their size distribution. We propose a spin-glass-inspired framework of self-assembly, where opinions are represented as multidimensional spins that dynamically self-assemble into groups; individuals within a group tend to share similar opinions (intragroup homophily), and opinions between individuals belonging to different groups tend to be different (intergroup heterophily). We compute the associated nontrivial phase diagram by solving a self-consistency equation for magnetization(combined average opinion). Below a critical temperature, there exist two stable phases: one ordered with nonzero magnetization and large clusters, the other disordered with zero magnetization and no clusters. The system exhibits a first-order transition to the disordered phase. We analytically derive the group-size distribution that successfully matches empirical group-size distributions from online communities.