SOE 4: Collective Dynamics

Time: Monday 15:00–16:00 Location: MA 001

SOE 4.1 Mon 15:00 MA 001

Resetting random walks may underlie movements of foraging ants — •Valentin Lecheval[1,2,4], Elva JH Robinson[3], and Richard P Mann[4] — [1]Institute for Theoretical Biology, Department of Biology, Humboldt Universität zu Berlin, Berlin, Germany — [2]Science of Intelligence, Research Cluster of Excellence, Berlin, Germany — [3]Department of Biology, University of York, York, UK — [4]School of Mathematics, University of Leeds, Leeds, UK

Animals that carry resources back to a particular site are called central place foragers, and they generally have a nest to which they bring resources. Many ant species are central place foragers, living in a nest and exploiting the surrounding environment. It is however unclear how their exploration behaviour relates to the emerging exploited area. Ants are a great opportunity to study the emergence of foraging territory from individual movements, given the potentially large number of scouting workers involved. Here, we introduce a resetting random walk model to depict ant exploration movements. We investigate various resetting mechanisms by varying how the probability to return to the nest changes with the number of foraging trips. We compare the macroscopic predictions to laboratory and field data. This reveals that the probability for scouting ants to return to their nest decreases as the number of foraging trips increases, resulting in scouts going further away as the number of foraging trips increases. Our findings highlight the importance of resetting random walk models for central place foragers and nurtures novel questions regarding the behaviour of ants.

SOE 4.2 Mon 15:15 MA 001

Impact of Temperature Change on Malaria Outbreaks — Morteza Afraz[1] and •Fakhteh Ghanbarnejad[2] — [1]Sharif University of Technology, Tehran, Iran — [2]Potsdam Institute for Climate Impact Research, Potsdam, Germany

Malaria, a vector-borne disease, remains a critical global health concern, particularly amid shifting climate patterns. This research delves into the intricate interplay between temperature variations and the dynamics of malaria transmission through an extensive analysis of deterministic mathematical models such as Ross-MacDonald and Parham and Michael models. Thus, we study the impact of temperature change on models' predictions, specifically the outbreak of malaria within populations. We explore fixed points, assessing their stability across varying temperature regimes, gauging the disease's sensitivity to temperature fluctuations, conducting bifurcation analyses, and elucidating phase transitions observable within these models. We employ empirical field data for temperature dependency and discuss which model's output aligns better with observed epidemiological trends. Finally, we present our predictions for the landscape of malaria transmission in the face of climate variations for different regions.

SOE 4.3 Mon 15:30 MA 001

Context-dependent self-tuning of distance to criticality in large fish shoals — •Yunus Sevinchan[1,2], David Bierbach[1,3], Carla Vollmoeller[1,2], Korbinian Pacher[3], Jens Krause[1,3], and Pawel Romanczuk[1,2] — [1]Science of Intelligence, TU Berlin — [2]Institute for Theoretical Biology, HU Berlin — [3]Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin

Collective biological systems – such as animal groups or neuronal networks – are presumed to operate at or near critical points at which they exhibit maximal sensitivity towards environmental cues.

We have studied large fish shoals of sulphur mollies (*Poecilia sulphuraria*) in their natural ecosystem in Southern Mexico, which perform collective diving cascades as a response to predation resulting in wave-like patterns on the water surface. We previously found these shoals to operate close to criticality. However, it remains an open question by which mechanisms they adapt to variations in their biotic and abiotic environment while balancing the trade-off between sensitivity and robustness towards external cues.

By analyzing a large video dataset of surface waves originating in response to synthetic stimuli or bird attacks, we relate wave characteristics to the macroscopic state of the shoal and its environment (e.g. physico-chemical water parameters). With these empirical observations informing an agent-based model, we further study possible mechanisms for self-tuning of distance to criticality. Our results help to better understand how changes in individual-level behavior enable collective-level adaptations to varying ecological contexts.

SOE 4.4 Mon 15:45 MA 001

Epidemic processes on self-propelled particles — •Jorge P. Rodríguez[1], Matteo Paoluzzi[2], Demian Levis[2,3], and Michele Starnini[4,5] — [1]Instituto de Física Interdisciplinar y Sistemas Complejos (IFISC), CSIC-UIB, Palma de Mallorca (Spain) — [2]Departament de Física de la Matèria Condensada, Universitat de Barcelona, Barcelona, Spain — [3]Universitat de Barcelona Institute of Complex Systems (UBICS), Barcelona, Spain — [4]CENTAI, Torino, Italy — [5]Departament de Física, Universitat Politécnica de Catalunya, Barcelona, Spain

Spreading processes often require spatial proximity between agents. The stationary state of spreading dynamics in a system of mobile agents thus depends on the interplay between the time and length scales involved in the spreading and the movement dynamics. We analyze the steady properties resulting from such interplay in a simple model describing epidemic spreading (Susceptible-Infected-Susceptible) on self-propelled particles (Run-and-Tumble). Proximity between particles shapes interactions, with the particle movement modifying the relative distances in the system. We analyze this problem from a continuum description of the system, validating those results by numerical simulations of an agent-based model. Focusing our attention on the diffusive long-time regime, movement changes qualitatively the nature of the epidemic transition. Indeed, the transition becomes of the mean-field type for agents diffusing in one, two and three dimensions, while, in the absence of motion, the epidemic outbreak depends on the dimension of the underlying static network.