On the role of space and stochasticity in co-evolutionary dynamics

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The formation of out-of-equilibrium patterns is a characteristic feature of spatially-extended, biodiverse, ecological systems. Intriguing examples are provided by cyclic competition of species, as metaphorically described by the 'rock-paper-scissors' game. Both experimentally and theoretically, such non-transitive interactions have been found to induce self-organization of static individuals into noisy, irregular clusters. However, a profound understanding and characterization of such patterns is still lacking. Here, we theoretically investigate the influence of individuals' mobility on the spatial structures emerging in rock-paper-scissors games. We devise a quantitative approach to analyze the spatial patterns self-forming in the course of the stochastic time evolution. For a paradigmatic model originally introduced by May and Leonard, within an interacting particle approach, we demonstrate that the system's behavior - in the proper continuum limit - is aptly captured by a set of stochastic partial differential equations. The system's stochastic dynamics is shown to lead to the emergence of entangled rotating spiral waves. While the spirals' wavelength and spreading velocity is demonstrated to be accurately predicted by a (deterministic) complex Ginzburg-Landau equation, their entanglement results from the inherent stochastic nature of the system. These findings and our methods have important applications for understanding the formation of noisy patterns, e.g., in ecological and evolutionary contexts, and are also of relevance for the kinetics of (bio)-chemical reactions.

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[2] T. Reichenbach, M. Mobilia, E. Frey, Noise and Correlations in a Spatial Population Model with Cyclic Competition, Phys. Rev. Lett. **99**, 238105 (2007).
[3] T. Reichenbach, M. Mobilia, E. Frey, Self-Organization of Mobile Populations in Cyclic Competition, [q-bio.PE/0801.1798].