Soft Living Active and Adaptive Matter

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Towards model-based control of active matter: active nematics and oscillator networks

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Abstract:

The richness of active matter's spatiotemporal patterns continues to capture our imagination. Shaping these emergent dynamics into pre-determined forms of our choosing is a grand challenge in the field. To complicate matters, multiple dynamical attractors can coexist in such systems, leading to initial condition-dependent dynamics. Consequently, non-trivial spatiotemporal inputs are generally needed to access these states. Optimal control theory provides a general framework for identifying such inputs and represents a promising computational tool for guiding experiments and interacting with various systems in soft active matter and biology. As an exemplar, I first consider an extensile active nematic fluid confined to a disk. In the absence of control, the system produces two topological defects that perpetually circulate. Optimal control identifies a time-varying active stress field that restructures the director field, flipping the system to its other attractor that rotates in the opposite direction. As a second, analogous case, I examine a small network of coupled Belousov-Zhabotinsky chemical oscillators that possesses two dominant attractors, two wave states of opposing chirality. Optimal control similarly achieves the task of attractor switching. I conclude with a few forward-looking remarks on how the same model-based control approach might come to bear on problems in biology.

Date:
31/01/2022

Time:
9:00 AM-10:15 AM (PT)

About the speaker:

Dr. Michael Norton is a Research Scientist in Physics at the Rochester Institute of Technology studying pattern formation in nonequilibrium and biophysical systems. He works with Prof. Moumita Das on the modeling of bacterial DNA-protein condensates.

Dr. Norton applies dynamical systems theory to control and design active materials with University of Nebraska-Lincoln collaborators Prof. Piyush Grover and Prof. Jae Sung Park through a recently awarded Department of Energy grant. Previously, he was a postdoctoral associate in Physics at Brandeis University with Prof. Seth Fraden and Prof. Michael Hagan. He holds a Ph.D. in Mechanical Engineering from the University of Pennsylvania where he was advised by Prof. Haim Bau.

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