Soft Living Active and Adaptive Matter

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Intrinsic Rhythms in a Giant Single-Celled Organism and the Interplay with Time-Dependent Drive, Explored via Self-Organized Macroscopic Waves

Eldad Afik

Abstract:

Living Systems often seem to follow, in addition to external constraints and interactions, an intrinsic predictive model of the world — a defining trait of Anticipatory Systems. Here we study rhythmic behaviour in Caulerpa, a marine green alga, which appears to predict the day/night light cycle. Caulerpa consists of differentiated organs resembling leaves, stems and roots. While an individual can exceed a meter in size, it is a single multinucleated giant cell. Active transport has been hypothesized to play a key role in organismal development. It has been an open question in the literature whether rhythmic transport phenomena in this organism are of autonomous circadian nature. Using Raspberry-Pi cameras, we track over weeks the morphogenesis of tens of samples concurrently, while tracing at resolution of tens of seconds the variation of the green coverage. The latter reveals waves propagating over centimeters within few hours, and is attributed to chloroplast redistribution at whole-organism scale.

Our observations of algal segments regenerating under 12-hour light/dark cycles indicate that the initiation of the waves precedes the external light change. Using time-frequency analysis, we find that the temporal spectrum of these green pulses contains a circadian period. The latter persists over days even under constant illumination, indicative of its autonomous nature. We further explore the system under non-circadian periods, to reveal how the spectral content changes in response. Time-keeping and synchronization are recurring themes in biological research at various levels of description — from subcellular components to ecological systems. We present a seemingly primitive living system that exhibits apparent anticipatory behaviour. This research offers quantitative constraints for theoretical frameworks of such systems.

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

About the speaker:

Dr. Eldad Afik is currently a Postdoctoral Scholar at the California Institute of Technology and a Research Specialist I at the Howard Hughes Medical Institute. He works with Prof. Elliot Meyerowitz on spatio-temporal dynamics in organismal development and interaction with the environment. He has been awarded the Biology and Biological Engineering Divisional Fellowship and the Zuckerman STEM Leadership Program. After obtaining a BSc. in Physics and Biology at the Hebrew University, his Ph.D. research at the Weizmann Institute of Science focused on complex flows, advised by Prof. Victor Steinberg.

Dr. Afik is interested in living systems as self-organizing and stabilizing out-of-equilibrium processes. He applies research approaches from Statistical Physics and Nonlinear Dynamics, seeking physical understanding of what is associated with biological function, adaptation, and homeostasis.

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