THE UNIVERSITY OF CHICAGO

Computational and Applied Mathematics & Statistics Student Seminar

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Telling time with a circadian clock: Light and temperature integration in cyanobacteria

Wednesday, January 21, 2026
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Rosenwald 011
1115 E 58th St

ABSTRACT

A simple circadian clock enables cyanobacteria to align photosynthesis, photoprotection, and metabolism with the Earth's varying day-night cycles. In the wild, these clocks must interpret correlated but not fully redundant environmental signals like luminance and temperature, which fluctuate across seasons, ecosystems, and latitudes. Recent work models the clock as an encoder–decoder that estimates biologically relevant quantities, such as time to sunrise/sunset or future light levels, providing a principled explanation for non-24-hour internal periods and their dependence on seasonal structure and latitude. Building on this mechanism, we simulate the KaiABC oscillator with a Stuart–Landau equation, which describes the dynamics of limit-cycle attractors near a Hopf bifurcation. By harnessing environmental signals like temperature and solar radiation as inputs to the model, we can chart the oscillator's trajectory in "clock" phase space. In particular, luminance changes drive shifts in the limit cycle's origin, while temperature scales the oscillation amplitude. This entrainment over time can be modeled as movement between orbits, providing a statistical basis for downstream prediction of crucial physiological variables. The model's predictive power is then enhanced by encoding oscillation nullification at sufficiently low temperatures, informed by experimental observations of lab-strain cyanobacteria. This additional temperature dependence on the bifurcation parameter more clearly captures seasonal variations in clock behavior across climates, prompting further investigation into the wide variety of circadian structures in nature.