Data assimilation and dynamical systems analysis of circadian rhythmicity and entrainment

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Abstract:Circadian rhythms are biological oscillations that align our physiology and behavior with the 24-hour environmental cycles conferred by the Earth's rotation. In this talk, I will discuss two projects from my recent sabbatical that focus on circadian clock cells in the brain and the entrainment of circadian rhythms to the light-dark cycle. Most of what we know about the electrical activity of circadian clock neurons comes from studies of nocturnal (night-active) rodents, hindering the translation of this knowledge to diurnal (day-active) humans. In the first part of the talk, we use data assimilation and patch-clamp recordings from the diurnal rodent *Rhabdomys pumilio* to build the first mathematical models of the electrophysiology of circadian neurons in a day-active species. We find that the electrical activity of circadian neurons is similar overall between nocturnal and diurnal rodents but that there are some interesting differences in their responses to inhibition. In the second part of the talk, we use tools from dynamical systems theory to study the reentrainment of a model of the human circadian pacemaker following perturbations that simulate jet lag. We show that the reentrainment dynamics are organized by invariant manifolds of fixed points of a 24-hour stroboscopic map and use these manifolds to explain a rapid reentrainment phenomenon that occurs under certain jet lag scenarios.

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