Theoretical Biology Seminar

Noise-Induced Bimodality in Self-Regulated Gene Networks with Nonlinear Promoter Transitions and Fast Dimerization

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Room 501, 5th floor, Bldg. #3
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We investigate noise-induced bimodal distributions in self-regulated gene networks with fast dimerization, where dimerized proteins enhance gene expression. Despite their fundamental role in gene regulation, the analytical study of bimodal behavior in these networks is particularly challenging due to the nonlinear features introduced by dimerization. To address this, we reformulate the system as a self-regulated gene expression model that approximates fast dimerization, where the transition rate from the promoter-off to the promoter-on state depends *nonlinearly* on protein levels. We introduce two key quantities: the *promoter activity ratio*, which quantifies gene activation at a given protein level, and the *mode detection ratio*, which identifies peaks in the probability distribution. Their governing recurrence relations reveal how promoter activity modulates the steady-state distribution, elucidating how stochastic effects drive multimodal protein distributions in self-regulated gene expression. Our approach provides a general framework for understanding noise-induced bimodality in gene networks with nonlinear interactions without relying on exact probability distributions, which are typically infeasible for nonlinear reaction rates, particularly in our case.

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