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ICTS Biophysics Seminar

Title : Autocatalytic reaction networks in ecology, evolutionary biology, and economics

Speaker : Praful Gagrani (The University of Tokyo, Japan)

Date : Monday, 04 August 2025

Time : 2:00 PM (IST)

Abstract : Autocatalytic reaction networks play a central role in self-replication and metabolism, appearing across systems from chemistry to ecology. These networks consume and net-produce their own components, capturing the essence of self-sustaining growth. In this talk, I will introduce a formalism to quantify autocatalytic strength and present our work on efficient algorithms to identify the strongest, maximal, and minimal autocatalytic subnetworks [1,2]. Applying these methods to the Formose reaction and E. coli metabolic datasets, we find that while the strongest autocatalytic subnetworks in early chemical systems tend to be minimal, evolution appears to favor metabolisms composed of interlinked minimal subnetworks whose collective strength exceeds that of any individual component. Throughout the talk, I will highlight the mathematical parallels between chemical reaction networks and economic systems, showing how autocatalysis naturally formulates the concept of a growing circular economy. I will conclude with an informal discussion of von Neumann's model of expanding economies [3], Eric Smith's perspective on the role of autocatalysis in evolutionary biology [4], and potential directions for future research.

[1] Blanco, Víctor, Gabriel González, and Praful Gagrani. "On the optimal growth of autocatalytic subnetworks: A Mathematical Optimization Approach." arXiv preprint arXiv:2412.15776 (2024).

[2] Gagrani, Praful, et al. "Polyhedral geometry and combinatorics of an autocatalytic ecosystem." Journal of Mathematical Chemistry 62.5 (2024): 1012-1078.

[3] Neumann, J. V. (1945). A model of general economic equilibrium. The Review of Economic Studies, 13(1), 1-9.

[4] Smith, E. (2023). Beyond fitness: the nature of selection acting through the constructive steps of lifecycles. Evolution, 77(9), 1967-1986.

Venue : Chern Lecture Hall

Zoom Link: <https://icts-res-in.zoom.us/j/95877106344?pwd=XkIvbAi2LS0998jKrX1BLn5c6kMUz6.1>

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