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A phase diagram for active phase separation

We present a minimal reaction-diffusion model that describes the behavior of molecules on a lipid membrane interacting with the surrounding cytosol. In this model, due to a feedback mechanism in chemical reactions, molecules phase separate into distinct domains. Unlike classical phase separation, this phenomenon is driven by enzymatic reactions, introducing an active component to the system. Using theoretical arguments, we derive a phase diagram that characterizes the stationary state of the system. We predict how the membrane's stationary-state concentration and the width of the phase coexistence region vary with reaction rates and system size. Additionally, we demonstrate how this model can describe the formation of domains enriched in specific molecular species, even in the presence of a crowded environment of diverse proteins. These theoretical predictions are validated through numerical simulations, offering insights into the mechanisms underlying membrane domain formation in biological systems.

Role

Master/PhD student

Primary author(s) : Mr. ANDREGHETTI, Damiano (Politecnico di Torino); Prof. BRAUNSTEIN, Alfredo (Politecnico di Torino); Prof. DALL'ASTA, Luca (Politecnico di Torino); Prof. GAMBA, Andrea (Politecnico di Torino)

Presenter(s) : Mr. ANDREGHETTI, Damiano (Politecnico di Torino)