Institut Charles Sadron — CNRS - UNISTRA - STRASBOURG

Séminaire

Mardi 21 avril 2026 à 10h30

Amphithéâtre Henri Benoît

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Emergent Material Properties in Biomolecular Condensates: From Viscoelasticity to Aging and Fibrillation

Biomolecular condensates formed via liquid–liquid phase separation are increasingly recognized as dynamic, functional compartments whose material properties are encoded by molecular sequence and modulated over time. While many condensates remain fluid-like, others undergo aging and tran- sition into viscoelastic, gel-like, or solid-like states, often associated with pathological aggregation. Understanding the physical mechanisms governing these transitions remains a central challenge. In this talk, we present a unifying framework that connects molecular-scale mechanisms of aging [1], sequence-encoded interactions [2], and non-equilibrium flux-driven processes [3] to the emergent material behavior of biomolecular condensates. First, using an energy landscape approach, we show how the organization of sticker interactions along polymer sequences-characterized by periodicity and disorder-controls the balance between viscous and elastic responses. Second, we demonstrate how aging processes, including solvent depletion, chain rigidification, and the lifetime of sticker interactions, drive a transition from liquid-like to elastic and solid-like behavior, with distinct vis-coelastic signatures. Finally, we introduce a non-equilibrium simulation framework that reveals how molecular flux and sequence-encoded β-prone motifs cooperatively drive amyloid nucleation at condensate interfaces, leading to diverse growth morphologies and arrested states. Together, these results establish biomolecular condensates as evolving soft materials whose fate is governed by the interplay of sequence, mechanics, and fibrillation. This perspective provides a unified physical basis for understanding functional organization and pathological solidification in intracellular condensates.

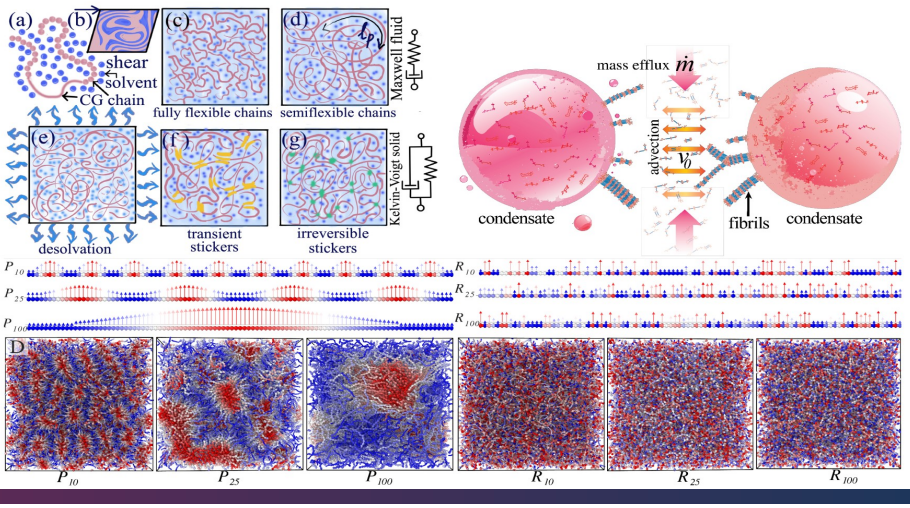

Figure:The schematic of models used to dissect the molecular driving forces of aging, fibrillation, and sequence patterning in biomolecular condensates.

Work performed with DA Potoyan at IOWA State University

[1] S. Biswas and D. A. Potoyan, Molecular drivers of aging in biomolecular condensates: Desolvation, rigidification, and sticker lifetimes, PRX Life 2, 023011 (2024).

[2] S. Biswas and D. A. Potoyan, Decoding biomolecular condensate dynamics: an energy landscape approach, PLOS Computational Biology 21, e1012826 (2025).

[3] S. Biswas and D. A. Potoyan, Amyloid nucleation at condensate interfaces is driven by β-motifs and molecular flux, bioRxiv (2026)

Les personnes souhaitant rencontrer l'orateur sont priées de prendre contact avec William Fall.

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