Institute of Science and Technology Austria

SLAM Seminar

Statistical physics of molecular sorting in living cells

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Molecular sorting is a fundamental process that allows eukaryotic cells to selectively concentrate specific chemical factors in appropriate cell membrane subregions, thus endowing them with different chemical identities and functional properties. A phenomenological theory of this molecular distillation process has recently been proposed [M. Zamparo, D. Valdembri, G. Serini, I. V. Kolokolov, V. V. Lebedev, L. DallAsta, and A. Gamba, Phys. Rev. Lett. 126, 088101 (2021)], based on the idea that molecular sorting emerges from the combination of: a) phase-separation-driven formation of sorting domains, and b) domain-induced membrane bending, leading to the production of submicrometric lipid vesicles enriched in the sorted molecules. In this framework, a natural parameter controlling the efficiency of molecular sorting is the critical size of phase-separated domains. In the experiments, sorting domains appear to fall into two classes: unproductive domains, characterized by short lifetimes and low probability of extraction, and productive domains, that evolve into vesicles that ultimately detach from the membrane system. It is tempting to link these two classes to the different fates predicted by classical phase separation theory for subcritical and supercritical phase-separated domains. I will discuss the implications of this picture in the framework of the previously introduced phenomenological theory of molecular sorting. To help in the analysis of experimental data, an operational definition of the critical size of sorting domains is proposed. Comparison with experimental results shows that the statistical properties of productive/unproductive domains inferred from experimental data are in agreement with those predicted from numerical simulations of a lattice-gas realization of the model, compatibly with the hypothesis that molecular sorting is driven by a phase separation process. Molecular sorting is further investigated on top of a fluctuating, topologically-varying membrane, simulated as a one-dimensional lattice which is allowed to undergo the topological transformations corresponding to fusion and detachment of molecule-loaded vesicles. In this framework, the interplay between molecules and membrane bending is explicitly taken into account and the membrane behaviour is studied as a function of the spontaneous curvature.

Thursday, May 25, 2022 11:00 - 12:00

Big Seminar Room B (big) I23.EG / Sunstone Building

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