Séminaire du LCP-A2MC

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Salle du département de Chimie
I.C.P.M. 1, boulevard Arago, Metz-Technopôle

Out-of-equilibrium synthetic cells: the future of active matter

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Colloidal active swimmers are broadly used as model systems to design microswimmers, yet their rigid and solid architecture limits their adaptability and functionality. A promising alternative is using bioinspired soft compartments for the design of cell-mimetic functional architectures while avoiding the complexity of living cells [1]. Here, I will showcase our latest results on driving giant unilamellar vesicles (GUVs) out of equilibrium via controlled external actuation to mimic and study life-like processes. We fabricate phase-separated Janus lipid vesicles, harnessing membrane fluidity to obtain reconfigurable motion]. Under external electric fields, these asymmetric compartments self-propel and display transient run-and-tumble-like dynamics arising from the coupling between mobile membrane domains and the field [2]. By tuning lipid composition and using temperature as an external trigger, we modulate membrane fluidity and phase separation, enabling in situ control over the frequency of tumble events [3]. Beyond motility, we exploit electric fields to induce controlled shape transformations and vesicle division events, showing that the same actuating scheme can access higher-order cell-like functions. In parallel, we use light to drive strong, localized membrane fluctuations, providing a route to study active, non-thermal shape dynamics in soft compartments. These results highlight synthetic cell membranes as versatile platforms in which different functions can be triggered using simple external fields [4].

[1] Volpe, G., Araújo, N.A.M., Guix, M., Miodownik, M., Martin, N., Alvarez, L., et al. Phys.: Condens. Matter., 37, 333501 (2025)
[2] Willems, V., Baron, A., Matoz-Fernandez, D., Wolisfberg, G., Dufresne, E. R., Baret, J.C, Alvarez, L.*. Soft Matter, 21, 6175-6185 (2025)
[3] Willes, V., Lylte, M., Deville, S., Joseph, E., Martin, N., Sprinkle, B.*, Alvarez, L*. (submitted)
[4] Willems, V., Moreno, P., Fojo, J. Rodriguez-Arco, L*., Alvarez, L*(under review, 2025)