Internship proposal – The Physics of information storage by polymers

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PhD possibility: yes
Keywords: Stochastic Thermodynamics, statistical physics, DNA

Summary: In the group, we are broadly interested in understanding how the laws of thermodynamics constrain biological processes like metabolism, adaptation and evolution using methods of non-equilibrium statistical physics. We are in particular currently working on autocatalytic chemical networks, in the context of research on the Origins of life [1,2], and on the modelling of adaptive strategies used by biological systems to cope with uncertain environments [3].

Biology uses extensively polymers like RNA and DNA to store important information. Physics constrains how fast and how reliably this information can be processed and stored, and it also introduces a fundamental asymmetry between the assembly and the disassembly process [4]. Current explosion in the production of information drives research of alternate technologies to optimize the storage of data. Information polymers like DNA represent a relevant option due to their high information density and storage energy efficiency. In this internship or PhD, we would like to explore general physics principles that control the formation of polymers of a given sequence. We will rely on theoretical methods of Statistical Physics, in particular Stochastic processes and Thermodynamics and on simulation techniques of chemical reactions.

This project will be conducted in close collaboration with Y. Rondelez in the Gulliver lab and A. Genot from the LIMMS lab at Tokyo university, who are developing the technologies of DNA computation and storage experimentally.

References :

[1] Universal motifs and the diversity of autocatalytic systems, A. Blokhuis, D. D. Lacoste, and P. Nghe, *PNAS*, 117, 25230 (2020)
[2] Emergence of homochirality in large molecular systems, G. Laurent, D. Lacoste, and P. Gaspard, *PNAS*, 118 (2021)
[3] Phase transitions in optimal strategies for gambling, L. Dinis, J. Unterberger, and D. Lacoste, *Eur. Phys. Lett.*, 131, 60005 (2020)
[4] Characterizing the Asymmetry in Hardness between Synthesis and Destruction of Heteropolymers, I. Kobayashi and S. Sasa, PRL, 128, 247801 (2022)