INTERNSHIP PROPOSAL

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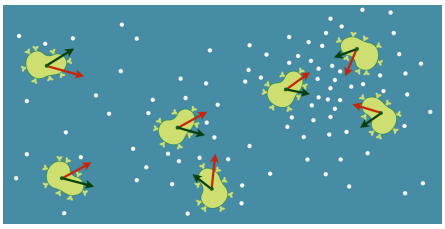
Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

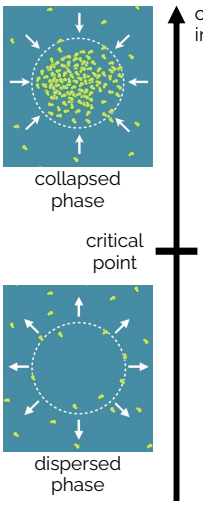
Self-organization of chemotactic cell assemblies

Understanding the self-organization of living systems is one of the biggest conceptual challenges of the present century. A generic mechanism that drives such organization is interaction among the individual elements — which may represent cells, bacteria, or even enzymes — via chemical signals. The ability of an individual cell to follow a gradient of chemicals is called chemotaxis [1].

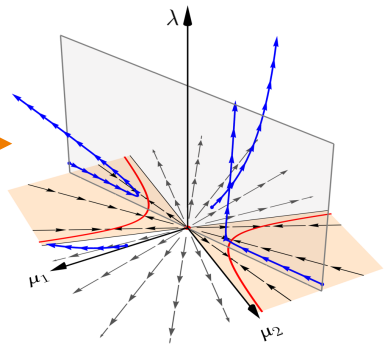
The interplay between cellular growth and cell-cell signaling is essential for the aggregation and proliferation of bacterial colonies, as well as for the self-organization of cell tissues. During this internship, we will consider microscopic and coarse-grained models for assemblies of chemotactic cells that produce their own chemical field, leading to effective long-range interactions between them. To characterize the nonlinear pattern formation stemming from the interplay between cell proliferation and cell-cell chemotactic signaling, several approaches could be considered:
- a numerical approach, based on simulations of the microscopic equations of motions or on solving the coarse-grained partial differential equations [2],
- a field-theoretical approach, that will allow characterizing the critical points and scaling properties of such colonies [3,4,5].



Schematic of chemotactic cells in interaction



Phase diagram



Renormalization group flow diagram

[1] Keller and Segel, J. Theor. Biol. 30, 225 (1971)
[2] Hillen and Painter, J. Math. Biol. 58, 183 (2009)
[3] R. Ben Alì Zinati, C. Duclut, S. Mahdisoltani, A. Gambassi, and R. Golestanian, EPL 136, 50003 (2022)
[4] S. Mahdisoltani, R. Ben Alì Zinati, C. Duclut, A. Gambassi, and R. Golestanian, Phys. Rev. Research 3, 13100 (2021)
[5] Jasper van der Kolk, Florian Raßhofer, Richard Swiderski, Astik Haldar, Abhik Basu, and Erwin Frey, Phys. Rev. Lett. 131, 088201 (2023)

Condensed Matter Physics: YES/NO Soft Matter and Biological Physics: YES
Quantum Physics: YES/NO Theoretical Physics: YES