TITRE : Shape formation in active liquid crystals by topological defects

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Ce stage peut être poursuivi en thèse : OUI

Si oui, la thèse est-elle financée : NON

SUJET du stage :

Monolayers of anisotropic cells exhibit characteristics of liquid crystals, such as long-range orientational order and topological defects [1]. The latter corresponds to domains in space where the orientation is ill-defined, see Fig. 1a. During the development of organisms, orientational order often influences morphogenetic events. However, the linkage between the formation of shapes and topological defects remains mostly unexplored. This holds specifically at the time scales relevant for tissue morphogenesis. Recent experiments suggest that topological defects organize collective behavior in biological materials [2,3] and Fig. 1b. Most notably, specific topological-defect configurations are spatially associated with several morphogenetic events during the regeneration of the animal *Hydra* [4]. This suggests that active liquid crystals present a novel shape-formation mechanism that is mediated by topological defects.

During this M2 internship, the student will aim to understand the linkage between active processes, topological defects and shape formation, Fig 1c. The student will apply the hydrodynamic theory of active gels [5] to an active liquid crystal within a 2D surface, which is a zeroth-order description for some biological tissues. Such theoretical description will include several active force-generation mechanisms that are allowed by symmetries, such as active nematic stresses as well as active torques.

1.- To start, the student will consider a minimal system composed of a 2D rigid flat surface with a single topological defect. The student will determine the mechanical patterns (e.g. velocity and stresses) arising from the interplay between topological defects and active force-generation mechanisms.

2.- In the next step, the student will relax the hypothesis of rigid surfaces in point 1 by considering 2D soft surfaces, which can deform under mechanical loading. Here, the student will aim to understand the characteristics of 3D morphological patterns as a function of the active force-generation mechanisms and for configurations with a single topological defect.

[1] G. Duclos, etal, Soft Matter, 10, 2346-2353, (2014), [2] T. B. Saw, etal, Nature, 544, 212-216, (2017), [3] K. Kawaguchi, etal, Nature, 545, 327-331, (2017), [4] Y. Maroudas-Sacks, etal, bioRxiv, (2020), [5] K. Kruse, etal, Eur. Phys. J. E, 16, 5-16, (2020)

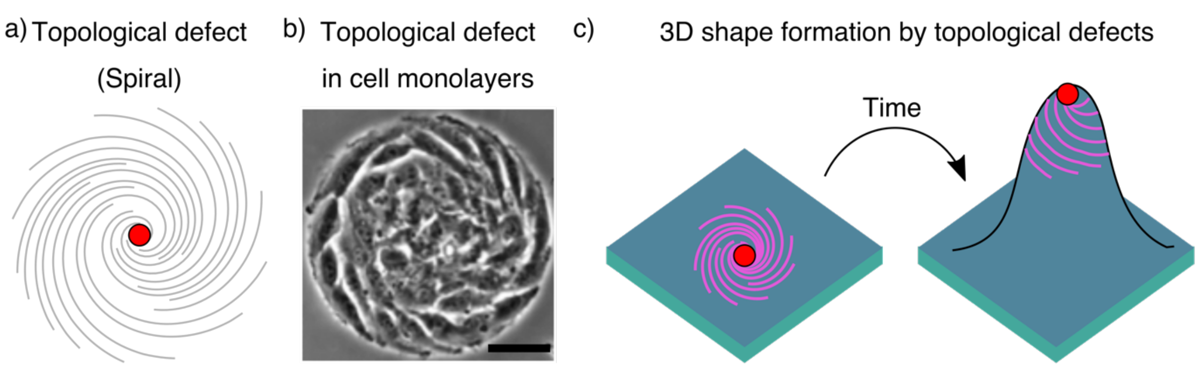

Figure 1: a) Spiral topological defect in a liquid crystal. Gray lines represent the director field and red circle represents the defect center. b) Spiral arrangement of myoblast cell monolayers. Scale bar 50 μm. c) Spiral topological defect on a 2D soft deformable surface can generate shapes through active processes.