A multi-scale modelisation of cell migration

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Cell migration plays a key role in many physiological processes, such as embryogenesis, wound repair, or metastasis formation. Cell migration is the result of a complex activity which involves many different time and space scales.

A recent study [3] has highlighted a universal process through which the structures responsible for migration reinforce cell polarisation, which favors a ballistic displacement.

In this talk I shall first describe our approach, which is inspired from [1], that allows describing the internal structures linked to migration as an active fluid. In this appraoch, the active character appears through boundary terms, which makes its original. Then, we shall see that the marker concentration obeys to a non-linear and non-local convection-diffusion equation, where the convection field corresponds to the fluid advection field. Finally, the marker distribution on the domain boundary exerts a feedback loop on the fluid.

From the mathematical viewpoint, it is possible to study the 1D model [2, 4]: global exstence or apparition of a singularity in finite time, non trivial steady states, long-time convergence. Some numerical trajectories in 2D will be presented first for rigid cells and then for deformable ones. Finally a comparison with real cell trajectories will be performed.

References

[1] K. Kruse, J. F. Joanny, F. Julicher, and J. Prost., *Contractility and retrograde flow in lamellipodium motion*, Phys Biol, **3**(2):1307, 2006.

[2] T. Lepoutre, N. Meunier and N. Muller, *Cell polarisation model: the 1D case*, J. Math. Pures Appl, 2014.

[3] P. Maiuri, et al., *Actin flows mediate a universal coupling between cell speed and cell persistence*. Cell 161, 374 386, 2015.

[4] N. Muller, M. Piel, J. Gonçalves-Sá, C. Guo, X. Jiang, V. Calvez, R. Voituriez, A. Murray and N. Meunier, *A predictive model for yeast cell polarization submitted to pheromone gradients*, PLOS Computational Biology, **14** (12), 2016.