BDR SEMINAR in Kobe

"CDB SEMINAR" and "QBiC SEMINAR" have been renamed "BDR SEMINAR".

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13:00-14:00, Auditorium C1F

Mechanics of cell crawling by means of force-free cyclic motion

Summary

Active particles, including biological cells and self-propelled Janus colloids, exhibit spontaneous motion without external forcing. This force-free condition, where the total force acting on the particle vanishes, is crucial, especially for micron-scale objects, for which inertia is negligibly small. For microswimmers at zero Reynolds number, the scallop theorem says that breaking reciprocality is necessary to achieve a net migration from internal cyclic motions [1].

In contrast to microswimmers that swim in a fluid environment, there also exist microorganisms that migrate on a substrate. Such crawling motion is often observed for eukaryotic cells, such as Dictyostelium cells and keratocyte. Typically, the mechanism of crawling motion is widely believed to consist of the following four steps [2]:

1. Protrusion of the leading edge due to actin polymerization
2. Adhesion of the leading edge to the substrate underneath
3. Deadhesion of the trailing edge from the substrate
4. Contraction of the cell body due to actomyosin contraction

Despite a number of studies on each step, the cycle of crawling mechanism itself has not been verified systematically.

We investigate the basic mechanism of cell crawling with a focus on the cycle of protrusion and contraction, as well as adhesion to the substrate underneath. We propose a mechanical model, where a cell is described by a set of subcellular elements connected by viscoelastic bonds [3]. For simplicity, we include the protrusion and contraction by a cyclic elongation of the bond, whereas the adhesion to the substrate underneath is represented as a change in the strength of the substrate friction. We highlight the importance of the phase shift of the substrate friction of each subcellular element with respect to the bond elongation to achieve a net locomotion.

[1] E. M. Purcell, Am. J. Phys., 45, 3 (1977).
[2] R. Ananthakrishnan and A. Ehrlicher, Int. J. Biol. Sci. 3, 303 (2007).
[3] M. Tarama and R. Yamamoto, J. Phys. Soc. Jpn. 87, 044803 (2018).

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