Informal Seminar Supported by Physical Biology

Modeling Geometrical Trajectories of Actin-based Motility

Fu-Lai Wen

National Central University Taiwan

Date：Friday, July 25, 2014

Time：17:00 ～ 18:30

Seminar Room：D2F Seminar room

Motility at the level of single cells is one of the most vivid features of life. Its biological significance is self-evident and its physical mechanism is an important ongoing research field. By means of conversion from chemical to mechanical energy in adenosine triphosphate (ATP) hydrolysis associated with the actin monomers, actin-based motility powers the motions of cells in a tissue and bacteria such as *Listeria monocytogenes* in the intracellular space. Although the protein interaction network for cell motility can be very complicated, not many of these proteins are essential for the motion of *Listeria*. The relatively small number of essential proteins in *Listeria*-type motion makes experimental studies of actin-based motility possible in artificial systems. Interestingly, both *in vivo* and *in vitro* experiments have observed various geometrical trajectories such as circles, S-shaped curves, serpentines, translating figure eights, and helical trajectories. Although the details of actin polymerization machinery have been identified, how the geometrical trajectories come from still remains elusive. To fill the gap between experimental observations and theoretical modelings, recently we proposed a model which can generate several geometrical trajectories observed in experiments. In our model, the force and actin density on the surface of the propelled object are influenced by the translation and the rotation of the object, which in turn is induced by the asymmetric distributions of those densities. We show that this feedback can destabilize a straight trajectory, leading to circular, S-shaped and other geometrical trajectories through bifurcations in the distributions of the force and actin density. When the instability is due to a pitchfork bifurcation, the resulting trajectory is a circle; a straight trajectory can also lose stability through a Hopf bifurcation, and the resulting trajectory is an S-shaped curve. The physical mechanism responsible for generating geometrical trajectories is unchanged when the system dimension increases from two dimensions to three dimensions. However, the extra rotational degrees of freedom of motility in three-dimensional space are found to give the object more rich dynamics. For example, in three dimensions a further pitchfork bifurcation of a circular trajectory can lead the object to move along a helical trajectory.

Contact: Tatsuo Shibata, Laboratory for Physical Biology, E-mail:tatsuoshibata@cdb.riken.jp, TEL: 078-306-3265（ext：5643）