第150回

附属社会創造数学センター主催
学術変革領域研究(A)「マルチモデルECM」共催

HMMCセミナー

Date : 2024年5月14日(火) 16:30～18:00

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Title : Self-organized aggregation and traveling wave in a kinetic transport model for run-and-tumble chemotactic bacteria

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Self-organized aggregation and traveling wave in a kinetic transport model for run-and-tumble chemotactic bacteria

Collective motion of chemotactic bacteria, such as *E. Coli*, relies, at the individual level, on continuous reorientation through alternating runs and tumbles. It has been established that bacteria modulate the length of their runs based on temporal sensing of extracellular chemical cues via intracellular signal transduction. This chemotactic behavior can be described by a kinetic transport equation with a scattering kernel explaining the velocity jump process during runs and tumbles [1].

Kinetic transport equations have been employed to elucidate the mathematics and physics underlying collective bacterial motions, including phenomena like traveling waves and pattern formation [2]. This study focuses on the self-organized aggregation and traveling wave of chemotactic bacteria emerging from an initially uniform state, akin to the volcano effect (i.e., the bimodal aggregation of chemotactic bacteria), initially observed in microscale aggregation experiments of E. coli [3].

We extended the Monte Carlo code for the kinetic transport equation [4] to incorporate non-instantaneous tumbling durations and adaptation dynamics of the bacteria's internal state [5]. We investigated the instability of the uniform state within a square periodic domain across a wide range of parameters concerning motility and chemotactic response.

We numerically elucidated the appropriate scaling of parameters for the occurrence of the volcano effect. Additionally, at this scaling, we derived a continuous-limit model capable of describing the volcano effect through asymptotic analysis of the kinetic transport model. Furthermore, we discovered a novel type of traveling wave induced by two distinct populations of running and tumbling cells.

References

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[4] S. Yasuda, J. Compt. Phys. **330**, 1022 (2017).

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