Numerical study of the volcano effect in chemotactic aggregation based on a kinetic transport equation with non-instantaneous scattering

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Aggregation of chemotactic bacteria under a unimodal distribution of chemical cues was investigated by Monte Carlo simulation based on a kinetic transport equation, which considers an internal adaptation dynamics as well as a finite tumbling duration. It was found that there exist two different regimes of the adaptation time, between which the effect of the adaptation time on the aggregation behavior is reversed; that is, when the adaptation time is as small as the running duration, the aggregation becomes increasingly steeper as the adaptation time increases, while, when the adaptation time is as large as the diffusion time of the population density, the aggregation becomes more diffusive as the adaptation time increases. Moreover, the parameter regime and scaling for the volcano effect (i.e., the bimodal aggregation), which was observed in an experiment of the micro-scale aggregation, was identified throughout the comparison between the MC results and the asymptotic analysis of the kinetic transport equation. That is, it is clarified that the volcano effect is generated due to the coupling of the diffusion, adaptation, and finite tumbling duration occurring at the large adaptation-time scaling.