Saddle-Node Bifurcation to Jammed State for Quasi-One-Dimensional Counter Chemotactic Flow

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The transition from a free flow state to a jammed state of counter chemotactic flow of particles in a quasi-one-dimensional path is investigated. One of the characteristic features of counter chemotactic flow is that the constituent particles spontaneously form a cluster, which blocks the path and causes a jammed state when the particle density is over a threshold value. This path-blocking cluster (hereafter, PBC) is maintained steadily, or dissolves itself after a finite duration time depending on the excessive density over the threshold one. In such a way, the time evolution of size of PBC governs the flux of a counter chemotactic flow. In this paper, on the basis of a numerically obtained relation between the leaving frequency of particles from the PBC and the reaching frequency of particles to the PBC, a Langevin equation model for time evolution of the number of particles in the PBC is introduced. Numerical simulation of this Langevin model reproduces the relations between the particle density and the flux obtained through a Stochastic Cellular Automata model, which results include the case of non-chemotactic counter flow as a limit. Moreover, this Langevin equation model indicates that the emergence of the jammed state in quasi-one-dimensional counter flow is taken as a saddle-node bifurcation, which indicates that the present transition has the same universality as Jamming transition in glassy systems.

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