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Phase segregation and symmetry breaking in out-of-equilibrium stochastic bidirectional transport systems

Motivated by the connections between the entrance and exit of several physical and biological stochastic transport mechanisms, we studied an open system of a two-species totally asymmetric simple exclusion process with narrow entrances, which assimilate the synergy of the particles with the surrounding environment through attachment/detachment process. We analyzed the model within the framework of mean-field theory, and examined complex steady state phenomena including boundary-induced phase segregation and spontaneous symmetry breaking for varied range of attachment and detachment rates. Our finding displays a prolific behavior, highlighting the crucial effect of attachment / detachment rates on symmetry breaking phenomenon. It is found that for their lower orders, the number of symmetrical and asymmetrical phase increases notably, while for their higher orders asymmetrical phases disappears, revealing the significant impact of bulk non-conserving processes on resuming or breaking of the symmetry between the two species. The theoretical findings are validated by extensive Monte Carlo simulations. The effect of the system size and symmetry breaking incident on the Monte Carlo simulation results has also been examined based on particle density distributions. The proposed framework provides a natural means to enhance our insight about various non-equilibrium systems present in nature.