Mathematical modelling of motor proteins transport in constrained environment

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Motor-proteins are molecular motors that drive the long-distance anterograde transport of cellular components along microtubule tracks. Kinesin, a motor protein have a critical role in neurogenesis and neuronal function. The destiny of kinesin motors after delivery of their cargoes is unknown. But recent study reveals that individual kinesin-1 motors are utilized for many rounds of transport by recycling [1]. Because of recycling the dynamics of the motor movement depend on the total concentration of free motors. Similar situation arises in many other systems like vehicular traffic and protein synthesis. TASEP is a discrete lattice model which in past has successfully described such non-equilibrium systems [2, 3]. In this study, we analyze the collective behavior of biological motors moving along two parallel and coupled lanes with recycling and constrained entrances using TASEP as a minimal model. We derive phase diagrams, density profiles and phase transitions theoretically utilizing mean-filed theory and validate them numerically by Monte Carlo simulation. It has been found that recycling of particles affects the system dynamics significantly. As a result , the spontaneous symmetry breaking phenomenon initiates even for very less number of particles in the proposed system. The regimes with broken symmetry emerges as shock-low density phase under limited resources, which is in contrast to the scenario with infinite number of particles. The critical values of a total particle number, beyond which various symmetrical/asymmetrical phases emerge/disappear are found.

References

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