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A model for biological transport gTASEP with OBC: some recent rigorous results

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Here we provide a brief overview of the applications of the Totally Asymmetric Simple Exclusion Process (TASEP) to various biological transport processes [1] and some recent developments in the study of the generalized TASEP (gTASEP) [2]. The TASEP is essentially a one-dimensional model where particles move unidirectionally along one-dimensional tracks, jumping probabilistically to the nearest empty neighboring site, subject to a hard-core exclusion interaction. In the generalized version, additional interaction is introduced between particles, modeling attractive or repulsive interaction between particles.

The process was first introduced in 1968 to model kinetics of protein synthesis [3], but later found a number of applications to other biological transport processes, e.g., the motion of molecular motor proteins, kinesin and dynein along microtubules, a process that accounts for nearly all intracellular transport in eukaryotic cells etc. Many other applications were suggested as well describing diverse phenomena, ranging from one-lane vehicular traffic flow, transport in chemical systems, forced motion of colloids in narrow channels, interface growth etc. Even though the TASEP is very simple model, it captures key characteristics of these systems while remaining an analytically solvable model.

The one-dimensional (T)ASEP (and its different versions) is a useful tool-model for understanding a variety of nonequilibrium phenomena [4]. It represents one of the simplest examples of self-driven many-particle systems with particle-conserving stochastic dynamics, exhibiting nontrivial behavior in one dimension through phase transitions between stationary nonequilibrium phases. The gTASEP enables the investigation of aggregation-fragmentation phenomena, fluctuations, and finite-size effects in nonequilibrium stationary states influenced by boundary conditions.

Over the past few years, research on nonequilibrium models has advanced rapidly; however, the aim remains to study model systems that provide more realistic approximations of real systems. Here, our focus is on one such model – the generalized TASEP (gTASEP) [2, 5].

Keywords: nonequilibrium model systems, nonequilibrium phase transitions, nonequilibrium stationary states, traffic flow, biological transport

References

[1] D. Chowdhury, A. Schadschneider, K. Nishinari, Physics of transport and traffic phenomena in biology: from molecular motors and cells to organisms, *Physics of Life Reviews*, 2:318–352, 2005.

[2] N. Zh. Bunzarova, N. C. Pesheva, A. M. Povolotsky, Phase diagram of generalized totally asymmetric simple exclusion process on an open chain: Liggett-like boundary conditions, *Physical Review E*, 109:044132, 2024.

[3] C. T. MacDonald, J. H. Gibbs, A. C. Pipkin, Kinetics of biopolymerization on nucleic acid templates, *Biopolymers*, 6:1–25, 1968.

[4] T. Chou, K. Mallick, R. K. P. Zia, Non-equilibrium statistical mechanics: from a paradigmatic model to biological transport, *Reports on Progress in Physics*, 74:116601, 2011.

[5] N. Zh. Bunzarova, N. C. Pesheva, J. G. Brankov, One-dimensional discrete aggregation-fragmentation model, *Physical Review E*, 100:022145, 2019.