Modified asymmetric exclusion process with internal particle states

Mikhail Tamm *[1,2], Pavel Lakidon[3]

[1] Moscow State University – Russia

[2] National Research University Higher School of Economics – Russia

[3] Skolkovo Institute of Science and Technology – Russia

Totally asymmetric simple exclusion process (TASEP) is an archetypic model of the transport phenomena in 1D: a linear lattice occupied by particles which hop in one direction at random provided that their hopping does not violate the excluded-volume constraint, i.e. the condition that there is no more than one particle per lattice site at any given time. We consider a following generalization of this model. Let particles have two internal states: ground and active. Activation of a particle (i.e., going from ground to active state) is a Poissonian stochastic process happening with a given fixed rate regardless of the particle's surroundings. Only active particles can move and relaxation (i.e., going from active to ground state) happens only when an active particle hops forward. If a particle tries to hop but it is prevented from that by the presence of a neighbor in the adjacent cell, it remains active. This definition generates a one-parametric class of models depending on the ratio of activation and hopping/relaxation rates. If activation is much faster than hopping, all particles are always active and the model reduces to classical TASEP. But if hopping is much faster than activation, new interesting behavior arises. In the latter case, the positions of particles in the steady state become highly correlated: a long queue of active particles tends to forming behind one in ground state, then when it finally jumps, all the queue of active particles immediately jumps, too, resulting in a long uninterrupted chain of ground-state particles, etc. We numerically study the properties of the steady state of this system on a ring (flow-density diagram, cluster size distribution, correlation functions, etc.), construct a 'cluster mean-field' theory, which qualitatively reproduces the numerical results, and discuss its possible generalization.

* - speaker