

Fluctuations in non-Markovian TASEP

The totally asymmetric simple exclusion process (TASEP) is simple stochastic particle system in one dimension where particles hop to the right with rate 1. Due to the exclusion interaction there is at most one particle per site and jumps onto occupied sites are forbidden. There is an excessive literature on this model (see e.g. [1] and references therein), which is a paradigmatic model for stochastic transport.

In applications to reality particles often represent more complex entities with internal degrees of freedom, such as stepping molecular motors on microtubules in the cell, or cars on a highway. Internal complexity leads to effective jump times of the particle which are non-exponential, making the model non-Markovian. For example, for stepping kinesin molecular motors there is data available from the group of Rob Cross at the Centre for Mechanochemical Cell Biology (see projects proposed by him).

The focus of this project is a theoretical study of the collective dynamics in the non-Markovian TASEP and the effect on large fluctuations in the system. In a recent study [2], an effective method to generate typical configurations realizing large current fluctuations in the system has been developed, based on classical cloning algorithms. Many realizations of the process are run in parallel and those with favourable behaviour are 'cloned', then the ensemble of realizations has to be interpreted correctly.

Details.

In a first step, a TASEP simulation with arbitrary waiting time distribution should be implemented, and typical values of quantities like the current should be measured. In coordination with projects of Rob Cross data from molecular motors could be studied in more detail here.

Then the algorithm in [2] should be understood for Markovian systems, and checked how this can be extended to non-Markovian models. While the typical behaviour should not differ much from Markovian models, for rare events one expects significant differences in typical realizations due to synchronous motion of the particles etc.

Of particular interest w.r.t. molecular motors are also models with internal degrees of freedom, which could also explain the different behaviour of microtubules under load which can exhibit pushing and pulling forces.

Collaboration, prospect for PhD project.

There are several directions in which this project can be extended for PhD, in particular in connection with molecular motors and the group of Rob Cross. There is also a collaboration with Rosemary Harris (Queen Mary, University of London) on large deviations and fluctuation theorems for non-Markovian models, which provides opportunities in a theoretical direction.

References.

- [1] R.K.P. Zia, J.J. Dong, B. Schmittmann, *Modeling Translation in Protein Synthesis with TASEP: A Tutorial and Recent Developments*, J Stat Phys (2011) **144**:405428. arXiv:1108.3312
- [2] C. Giardinà, J. Kurchan and L. Peliti, *Direct evaluation of large-deviation function*, Phys. Rev. Lett. **96** (2006) 120603. arXiv:cond-mat/0511248
- [3] C. Giardinà, J. Kurchan, V. Lecomte and J. Tailleur, *Simulating rare events in dynamical processes*, J. Stat. Phys. **145**, 787 (2011). arxiv:1106.4929

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