Nonstationary generalized TASEP in Kardar–Parisi–Zhang and jamming regimes.

A.E. Derbyshev A.M. Povolotsky

Bogoliubov laboratory of theoretical physics, Joint Institute for Nuclear Research

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Introduction

Kardar-Parisi-Zhang (KPZ) universality class is the large class of the non-equilibrium phenomena, like random surface growth, traffic flows and polymers in random media, characterized by the same large scale behavior. Examples are turbulent liquid crystals, crystal growth on a thin film, bacteria colony growth, paper wetting, crack formation and growth of burning fronts etc. They are characterized by two critical exponents describing the time scaling of fluctuations and correlations, which are $\alpha = 1/3$ and $\beta = 2/3$ in $D = 1 + 1$ space-time dimension respectively.

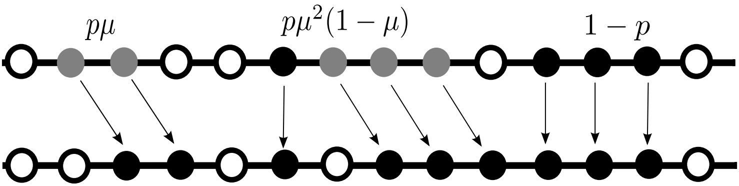
The field of integrable stochastic interacting particle models is a laboratory for studying nonequilibrium phenomena. They admit obtaining exact solutions, which provide the universal laws in the scaling limit.

GTASEP is a generalization of the prominent traffic model, the totally asymmetric simple exclusion process model (TASEP) belonging to the KPZ universality class with an additional attractive interaction between particles added. The aim of current research is to study how the attractive interaction affects the KPZ universality.

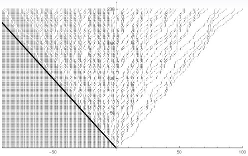
Definition of GTASEP model

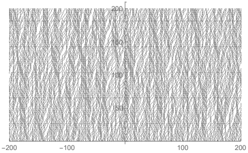
Each lattice site can be occupied by, at most, one particle. Particle configurations evolve in discrete time with clusterwise backward-sequential update:

1. the first particle of the cluster decides to jump to $x+1$ with probability p or to stay in x with probability $1-p$;
2. if the first particle has jumped, the second particle of the cluster follows it with probability μ or stays with probability $1-\mu$, and so does every next particle of the same cluster if the previous particle has jumped;
3. if some particle has decided to stay, all the other particles to the left of it within the same cluster stay with probability 1.



Two scaling regimes.



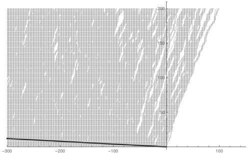


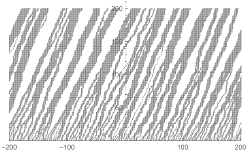
KPZ regime , $\mu < 1$

In the case of moderate attraction, $\mu < 1$, the fluctuations and correlations of particle positions at large time $t \to \infty$ are on the KPZ scales, $t^{1/3}$ and $t^{2/3}$.

$$x_n(t) \simeq t\chi(\theta) + \kappa_f \mathcal{X}(u) t^{1/3}$$

where $n = t\theta + t^{2/3}\kappa_c u$, with $\theta > 0$ fixed:

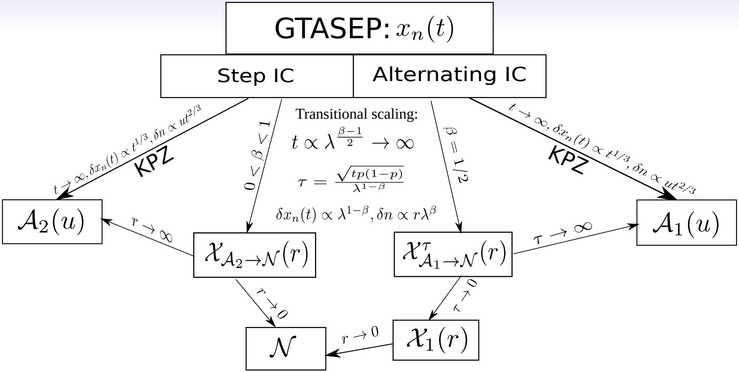




Transitional regime , $\mu \to 1$

When the attraction is strong, particles form macroscopic clusters that move diffusively, with Gaussian fluctuations on the scale $\sqrt{t}$ at large time $t \to \infty$. Under simultaneous limit $t \to \infty, \mu \to 1$, with $\tau_\beta = (1-\mu)^{1-\beta}\sqrt{tp(1-p)}$ and $n = [r\lambda^\beta]$ with r fixed:

$$x_n(t) - x_n(0) \simeq pt + \sqrt{p(1-p)t}\,\mathcal{X}(r), \qquad (1)$$



- Exact formulas for distributions of a finite number of particles are derived.
- We identify two non trivial scaling regimes.
- For $\mu < 1$ the scaling behavior is usual for KPZ class characterized by processes known from the random matrix theory.
- For $\mu \to 1$ there is a transitional regime characterized by novel random processes, which interpolate between the KPZ universality class and Gaussian fully correlated particle motion.

List of publications

- Derbyshev A. E. , Poghosyan S. S. ,Povolotsky A. M. Priezzhev V. B. The totally asymmetric exclusion process with generalized update J. Stat. Mech. P05014 2012
- Derbyshev A. E. ,Povolotsky A. M. Priezzhev V. B. Emergence of jams in the generalized totally asymmetric simple exclusion process Phys. Rev. E 91, 022125 2015.
- Derbyshev A. E. ,Povolotsky A. M. Nonstationary generalized TASEP in KPZ and jamming regimes arXiv:2012.00814 2020. submitted to J. Stat. Phys.