Re-entrant phase transition in the TASEP with parking spots

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Understanding vehicular dynamics in urban areas is a central task for modifying urban space planning and implementing effective policies to optimize transportation time and reduce carbon dioxide emissions. Incorporating parking slots is crucial as parking maneuvers and cruising for parking impact vehicular flow [1]. From a microscopic perspective, vehicular traffic can be treated as interacting particles driven far from equilibrium. One of the simplest out-of-equilibrium models is the Total Asymmetric Exclusion Process (TASEP), which has been analytically solved with open boundaries [2].

To focus specifically on urban traffic, we propose a TASEP variant with open boundary conditions that includes a parking spot at each site, occupied by at most one particle, see figure 1. Two types of particles have been considered: slow particles caracterized by a hopping rate p_A that attempt to park at a given rate q_A if a parking spot is available, and fast particles with a hopping rate $p_B \geq p_A$ that cannot park. Parked particles return to the road as fast particles at a specified rate q_B, if feasible. This general model encompasses several previously studied TASEP variants. Dynamical properties and phase diagram have been investigated using Kinetic Monte Carlo simulations, exact diagonalization of the stochastic matrix, and mean field theory.

We have shown the non-monotonic behavior of the current with respect to the input rate and parking rate, leading to re-entrant phase transitions. This novel behavior remains robust when introducing disorder in the parking and leaving rates, as well as when employing a different update scheme, namely the parallel update which increases the correlation between neighbouring particles. This update has been widely used specifically in the context of vehicular traffic [3]. Shifting the parking area within the bulk reveals properties similar to TASEP with a finite-size bottleneck [4] which can be controlled through the parking and leaving rates.

These non-trivial dynamics underscore the importance of carefully choosing these rates and the placement of parking spots to maximize vehicular flow.

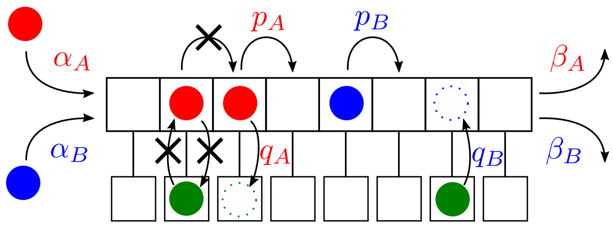

Fig. 1. TASEP with parking spot with two kind of particles (red and blue circles) see text. Green circles correspond to parked particles.

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