Statistical mechanics of steady state traffic flow

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Statistical mechanics of a small system of cars on a single-lane road is developed. A discrete particle hopping model, not characterized by a kinetic equation, but by conditional probabilities of car velocities depending on the distance and velocity of the car ahead, is used. The model is a generalization of a reformulated ASEP model in terms of conditional probabilities of particle velocities. Similarly as in the ASEP model, all the spatial configurations of cars in a homogenous system described by our model are assumed to be equally probable. Nontrivial spatial car distributions are obtained by fixing the mean car velocities in a group.

Distribution of car velocities for various densities of a group of cars is derived as well as the probabilities of density fluctuations. For cars with high braking ability, free-flow and congested phases are found. Platoons of cars are formed for a system of cars with inefficient brakes. Indications for a first order phase transition between free-flow and congested phase are presented.

The method is also applied to a disordered system of cars consisting of two kinds of vehicles of different maximal velocities. The behaviour of the system is strongly influenced by presence of slow cars even in small percentage, and the distribution of car velocities is radically changed.