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Congested traffic patterns of two-lane lattice hydrodynamic model with partial reduced lane

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HIGHLIGHTS

- A two-lane lattice hydrodynamic model with partial reduced lane is proposed.
- A variety of congested traffic patterns such as pinned localized cluster (PLC), moving local cluster (MLC), triggered stop-and-go(TSG), etc. are reproduced by numerical simulation.
- The sensitive coefficient λ of the upstream–downstream density difference dominates an important role in resulting in various congested traffic patterns.

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ABSTRACT

In this paper, we proposed a lattice hydrodynamic traffic model to study the congested traffic patterns on two-lane with the partial reduced lane via considering the upstream–downstream density difference and lane-changing rule. Using the lattice hydrodynamic model with the partial reduced lane for numerical simulation, various complex congested traffic patterns such as triggered stop-and-go (TSG), pinned localized cluster (PLC), oscillatory congested traffic (OCT), homogeneous congested traffic (HCT), homogeneous synchronized traffic (HST) and moving localized cluster (MLC) can be reproduced. Moreover, it is found that the sensitive coefficient λ of the upstream–downstream density difference plays a main role in generating these congested traffic patterns.

1. Introduction

The contradiction caused by the relative delay in traffic construction compared with the rapid development of social economy has drawn much attention and induced intensive investigation of traffic flow theory [1–3]. In the last decade, a variety of traffic models, such as the car-following model, the cellular automaton model, the gas kinetic model and the hydrodynamic model, etc., have developed [1–3]. Among these, the lattice hydrodynamic model is a typical macroscopic traffic model and has been extensively applied to investigate the characteristics of traffic flow in many aspects. The lattice hydrodynamic (LH) model first proposed by Nagatani [4,5] in 1998 incorporates the idea of the microscopic optimal velocity model, and is a simplified version of the macroscopic hydrodynamic model. Nagatani has extended the one-dimensional lattice hydrodynamic model to the two-dimensional one to investigate the two-way traffic like BML(Biham–Middleton–Levine) model [6]. Since then many the modified lattice hydrodynamic model by introducing important real effects and environmental parameters, such as two-lane traffic flow lattice model [6,7], backward-looking effect [8], the driver's delay

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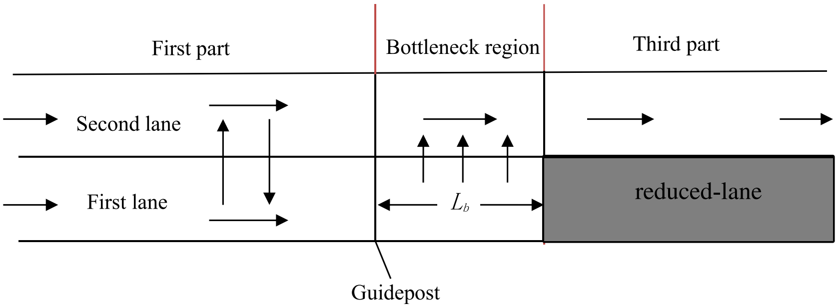

Fig. 1. The sketches of two-lane with the partial reduced lane.

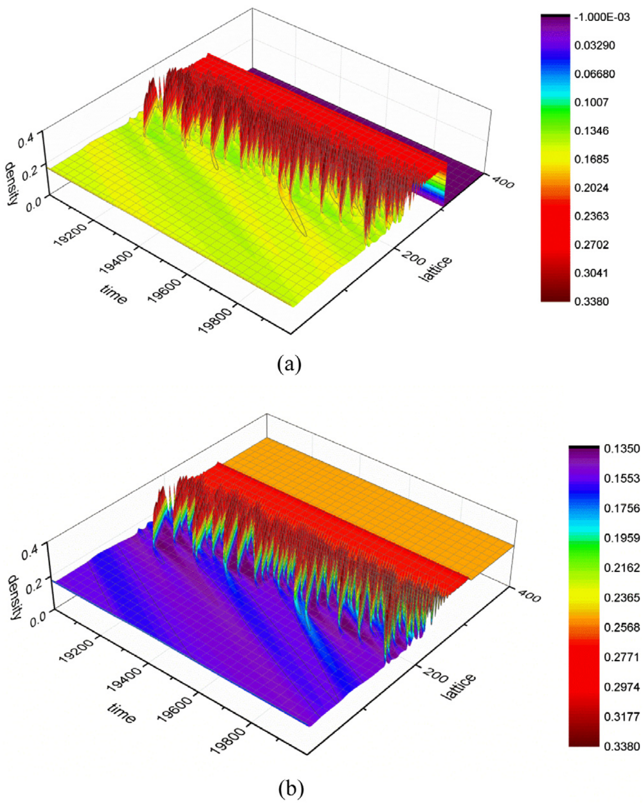

Fig. 2. The spatiotemporal-density evolutions of PLC on (a) the 1st lane and (b) the 2nd lane for $\rho_h = 0.25$, $Q_b = 0.12$, $\lambda = 0.1$.

effect [9,10] , the effect of interruption probability [11] and drivers anticipation effect [12] with passing, etc, have been proposed. Tang et al. [7] proposed the improved two-lane lattice hydrodynamic traffic model. Ge et al. [8] considered the backward looking effect in the lattice hydrodynamic models and carried out the theoretical analysis and numerical simulation. The study confirmed the backward looking stable effect to some extent. Redhu & Gupta [11–16] systematically studied jamming transitions, the effect of forward looking sites, the effect of interruption probability and the driver's anticipation effect with passing, etc. in LH model of traffic flow. Peng [17,18] studied the lateral effects of the lane width and considered the driver's anticipation effect to induce the wide-moving jams. In refs of [9], Ge et al. derived TDGL (time-dependent Ginzburg–Landau) equation in lattice hydrodynamic model by considering driver's physical delay and confirmed the relation of traffic jams with phase transition of traffic flow. Kang et al. [10] proposed a new lattice hydrodynamic traffic flow model with explicit drivers' physical delay and illustrated the drivers physical delay affects stability of traffic flow. In recent years, the one-dimensional lattice hydrodynamic model was also extended to traffic control [19–23]. In addition, based on car-following model, Cheng, Zheng et al. [24–27], Zhu et al. [28,29] and Tang et al. [30,31] explored many significant works about traffic control, traffic running cost and route choice, etc.