The influence of two-lane coupling intensity on one-lane traffic flow

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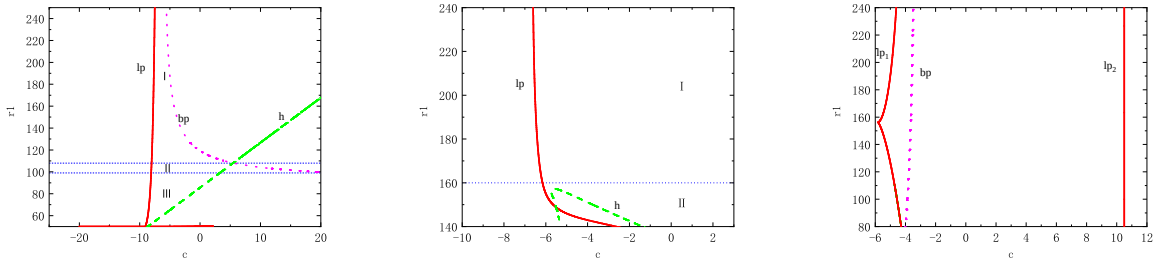
Abstract. Bifurcation of traffic flow involves complex dynamic characteristics of the system. In order to understand the complex traffic phenomena, three continuum models of two-lane traffic flow are studied. We investigate the effect of the coupling strength of two-lane on the stability of traffic flow based on the three models. By means of one-parameter and two-parameter bifurcation analysis, the influence of the coupling strength on the bifurcation structure of the system is discussed, and the dynamic mechanism of traffic flow is further discussed. We can provide explanation of the association between lane change rate and density using time series comparison analysis. The study showed that the stability of traffic flow is significantly influenced by the coupling strength of two-lane. When traffic congestion occurs in a two-lane traffic system, considering the change in the bifurcation structure into view enables drivers to adequately modify their driving behavior.

Introduction

In actual traffic, multiple lanes are the main form. In order to study the complex phenomenon of multi-lane traffic flow, some multi-lane traffic models are proposed to study the lane change. Peng et al.[1] introduced velocity gradient viscosity term and lane change term into the model to study the change behavior of shock wave and rarefied wave. However, the applicability of these models to actual traffic is limited, and the two-lane model considering drivers' physiological and psychological factors is also very worthy of attention and research. Therefore, three two-lane models considering driver memory are proposed in this paper. Bifurcation theory is widely used in the study of one-lane stability. Delgado et al.[2] proved the existence of degenerate Bogdanov-Takens bifurcation in Kerner-Konhauser model, thus explaining the existence of Hopf bifurcation. In order to describe the traffic flow phenomenon caused by bifurcation in detail, Ren et al.[3] studied Hopf bifurcation and explained stop-and-go phenomenon. Therefore, the effect of coupling strength on lane change rate can be analyzed by bifurcation theory.



(a) the traffic lane $x_1 = x_2$ (b) the traffic lane $x_1 \neq x_2$ (c) the traffic lane $x_1 \ll x_2$

Figure 1: Two-parameter bifurcation of wave velocity c and coupling strength $r1$.

Results and disscussion

Drawing on the actual traffic phenomena, we used the structure comparison method to conduct a comparative study of the two-lane traffic flow models with average speed, general speed and fast-slow speed when the inflow rate is zero. Here, only the bifurcation structures of the models with average speed are given, as shown in Figure 1. So, different two-lane traffic phenomena will have different bifurcation structures. The basic properties of the bifurcation structures are discussed by time series analysis, different dynamics phenomena in the three continuum models of two-lane traffic flow are identified and the effect of the coupling strength of two-lane traffic on the lane change rate is analyzed using bifurcation theory. A foundation is laid for further understanding of the characteristics of traffic flow and further paves the way for the optimal development of traffic flow models.

References

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[3] Ren W.L., Cheng R.J., Ge H.X. (2021) Bifurcation analysis for a novel heterogeneous continuum model considering electronic throttle angle changes with memory. *Appl Math Comput* **401**: 126079.