From a car-following model with reaction time to a macroscopic convection-diffusion traffic flow model

A. Tordeux*

Forschungszentrum Juelich and Wuppertal University

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Abstract

In this work, we derive a continuum macroscopic traffic flow model from a microscopic car-following model. The microscopic model is based on a non-decreasing and positive optimal velocity function and a reaction time parameter [1]. The corresponding macroscopic model results in a convection-diffusion equation. More precisely, the convection is described by the optimal velocity while the diffusion term depends on the reaction time. The macroscopic model is discretized using a Godunov scheme and the linear stability conditions for the homogeneous solution of the numerical schemes are provided. The conditions match the ones of the car-following model for specific values of the spatial discretisation step. Simulations are carried out with sufficiently small space and time discretisation to hold the CFL condition. The results show that the dynamics of the microscopic model are well recaptured by the macroscopic approach even if the homogenization assumption, see [2], does not hold (cf. Figure 1). The transition to collision-free stop-and-go dynamics, that is a crucial characteristic of the microscopic model when the reaction time is sufficiently large, is also obtained with the macroscopic model. In the inhomogeneous case, both models describe limit-cycles in stationary states, with hysteresis curves in the fundamental flow/density diagram (see [3, 4]). Consequently, a scattering in this relationship occurs (see also [5, 6]), for which we compute the bounds. Finally comparison of these bounds to real pedestrian and road traffic data are presented.

References

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*a.tordeux@fz-juelich.de

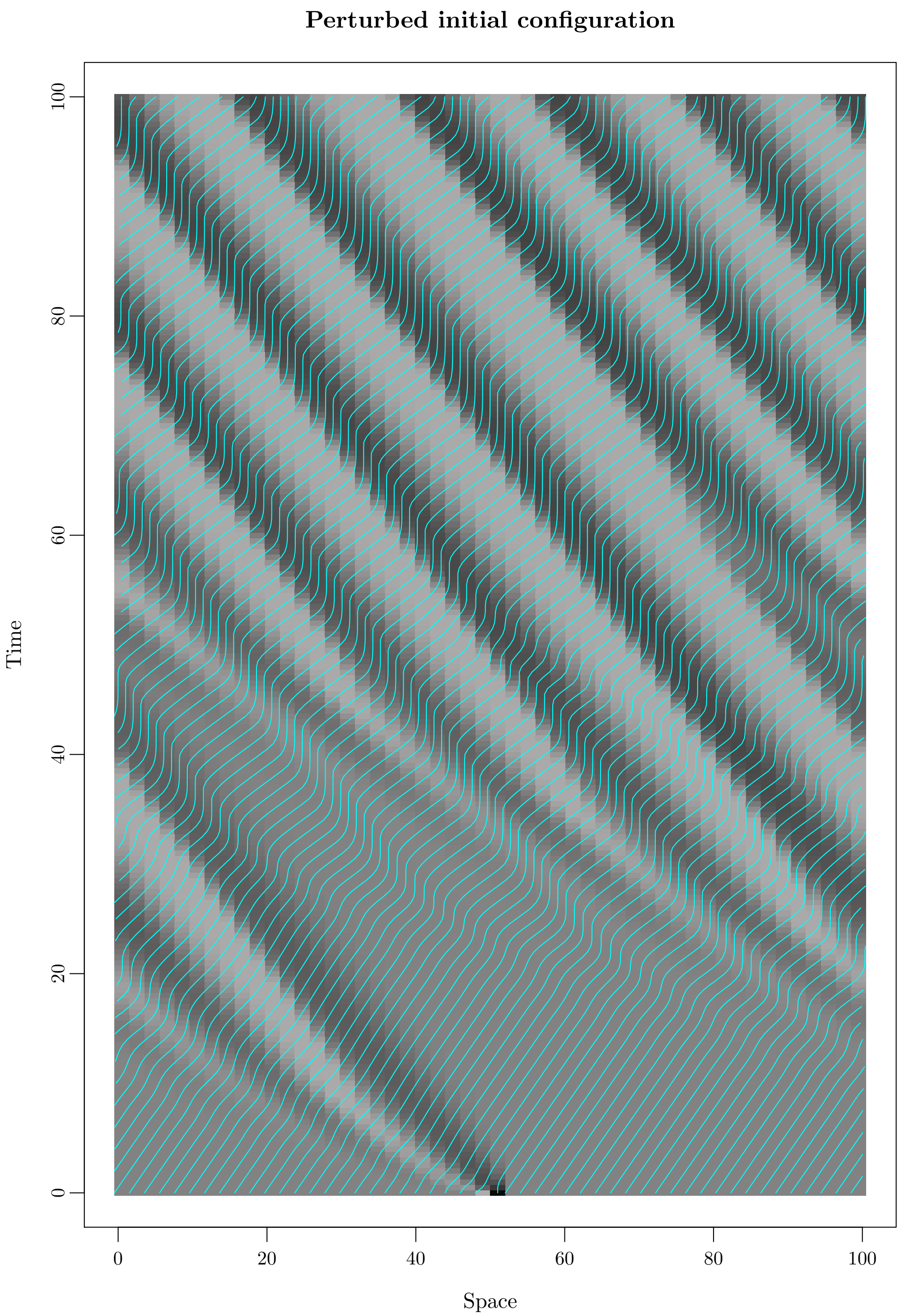

Figure 1: Trajectories of the microscopic model (cyan curves) and the time series for the density by cell for the discrete macroscopic model (gray levels) for perturbed initial conditions.