Vehicular Dynamics and Thermodynamics of Driven Systems

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Application of thermodynamics to driven systems is discussed [1].

As particular examples, simple traffic flow models are considered. On a microscopic level, traffic flow is described by Bando's optimal velocity model in terms of accelerating and decelerating forces. It allows to introduce kinetic, potential, as well as total energy, which is the internal energy of the car system in view of thermodynamics. The latter is not conserved, although it has certain value in any of two possible stationary states corresponding either to fixed point or to limit cycle in the space of headways and velocities.

On a mesoscopic level of description, the size n of car cluster is considered as a stochastic variable in master equation. Here $n = 0$ corresponds to the fixed–point solution of the microscopic model, whereas the limit cycle is represented by coexistence of a car cluster with $n > 0$ and free flow phase. The detailed balance holds in a stationary state just like in equilibrium liquid–gas system. It allows to define free energy of the car system and chemical potentials of the coexisting phases, as well as a relaxation to a local or global free energy minimum. In this sense the behaviour of traffic flow can be described by equilibrium thermodynamics. We find, however, that the chemical potential of the cluster phase of traffic flow depends on an outer parameter – the density of cars in the free–flow phase. It allows to distinguish between the traffic flow as a driven system and purely equilibrium systems.

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