Jam formation and collective motions of self-driven particles

Yuki Sugiyama

Department of Complex Systems Science,
Graduate School of Information Science, Nagoya University
sugiyama@phys.cs.is.nagoya-u.ac.jp

Abstract

Formation of a traffic jam is one of the most typical phenomena related to crowd dynamics. A car in highway traffic is understood as a self-driven particle, whose velocity is controlled not to collide with the car in front. In the physical point of view, the system of traffic flow is non-equilibrium dissipative system with asymmetric interaction of particles. Jam formation is caused by the effect of collective motions of such self-driven particles. The mechanism is shown by theoretical analysis as well as experiments.

Optimal Velocity Model is a minimal model formulated with Newtonian equation of particles in nonlinear asymmetric interaction with dissipative (viscous) term. The model describes a lot of phenomena originated in collective motions with asymmetric interactions in energy-momentum non-conserved dissipative system of particles, such as traffic jam, crowd motion of pedestrians, group formation of collective bio-motions, adaptive pattern formation of moving self-driven particles, etc.

There are general mathematical properties among the mechanisms of above phenomena. Emergence of such macroscopic moving objects occurs as dynamical phase transition or bifurcation. The number of particles N (or density) is a control parameter for the instability of the homogeneous motion in a system. The small- N is large enough degree of freedom in such many-particle systems. They contrast sharply with energy-momentum conserved systems.