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SPECIAL ISSUE ON MATHEMATICAL MODELS FOR COLLECTIVE DYNAMICS

A fascinating feature of large groups of autonomous agents is their ability to form organized global patterns even when individual agents interact only at a local scale. This behavior is usually referred to as *self–organization*: the emergence of complicate and very efficient group configuration by sophisticated yet simple individual interaction rules. The analysis of such models is particularly devoted on understanding the mechanisms leading from local rules to global phenomena, as well as identifying the resulting global pattern formation. Examples are found in different disciplines: animal groups in biology, crowd dynamics (vehicles and pedestrian) and social networks (opinion formation).

In this context, the models can be classified as first–order models and second–order models. In the former, the variables of interest can be, according to the different applications: opinions, positions, market shares or wealth of the agents. In that case, the state of each agent is affected by neighboring agents' states in the state space.

On the other hand, in second–order models, the variables of interest are the velocities, obtained as the time derivatives of the positions. Such models stem mostly by writing Newton-like equations to model "social" or real forces. Each agent's velocity is affected by the velocities of the other agents, possibly only whose positions are close in the state space. Among these models one of the most studied is the Cucker–Smale model.

First-order models can give rise to patterns such as consensus (i.e. agreement of all states), polarization (i.e. disagreement between two opposite parties) or clustering (i.e. break–down of the opinions into several subsets), while for second–order models, the total consensus leads to bound for positions and alignment of velocities (i.e. the group moves with the same velocity).

Mathematically, one of the most interesting problem is the study of mean-field limit equations, e.g. Vlasov-type kinetic equations. Another emerging research line is that of controlled equations: the concept of sparsity plays an important role since in applications only a small number of agents can be controlled.

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