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From individual to collective behaviour of coupled velocity jump processes: a locust example

A class of stochastic individual-based models, written in terms of coupled velocity jump processes, is presented and analysed. This modelling approach incorporates recent experimental findings on behaviour of locusts. It exhibits nontrivial dynamics with a phase change behaviour and recovers the observed group directional switching. Estimates of the expected switching times, in terms of number of individuals and values of the model coefficients, are obtained using the corresponding Fokker-Planck equation. In the limit of large populations, a system of two kinetic equations with nonlocal and nonlinear right hand side is derived and analyzed. The existence of its solutions is proven and the systems long-time behaviour is investigated. Finally, a first step towards the mean field limit of topological interactions is made by studying the effect of shrinking the interaction radius in the individual-based model in the large population limit.