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Coarse-graining of collective dynamics models

In this talk we will report on some new individual-based models of collective dynamics and their coarse-graining into continuum models. The applications span from collective cell dynamics (such as social bacteria or sperm) to flocking of birds or fish. Models of social behavior are best set up at the individual scale where behavioral rules can be easily introduced and tested. However, the complexity of individual-based models increases rapidly with the number of individuals and their calibration or control can hardly be implemented at this level. To overcome this limitation, one often uses continuum model that describe the system through average quantities such as densities or mean orientation. But the downside of most models in the literature is that the link between the rules at the individual behavior and the coefficients in the macroscopic model are not known exactly and are at best extrapolated from heuristic consideration. Here, we propose a systematic and mathematical rigorous way to derive continuum models from collective dynamics models. It relies on the introduction of a new concept, the generalized collision invariants, which permit to overcome the lack of physical invariance in most systems undergoing collective dynamics. In this talk, we will review some recent developments of these concepts and how they can be used to model systems of practical scientific importance.