Particle-based models with volume-exclusion constraints and applications to biology

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Particle systems are widely found in biology, for example, in cell tissues, flocks of birds or herds of sheep. In this seminar I will present a particle-based modelling framework which relies on simple behavioural rules, such as, 1) two particles cannot overlap with each other and 2) the particles seek a minimum of a given confining potential at all times. The dynamics is driven by the evolution of the confining potential and changes in particle characteristics, such as size. The model involves a non-convex minimization problem which will be tackled with the recently proposed damped Arrow-Hurwicz algorithm. The derivation and convergence analysis in 1D of this algorithm will be presented. Finally, these tools will be used to simulate two different systems: 1) a large system of up to 1 million particles undergoing ballistic aggregation in a torus and 2) the evolution of the size and shape of a pseudo-stratified epithelial tissue.