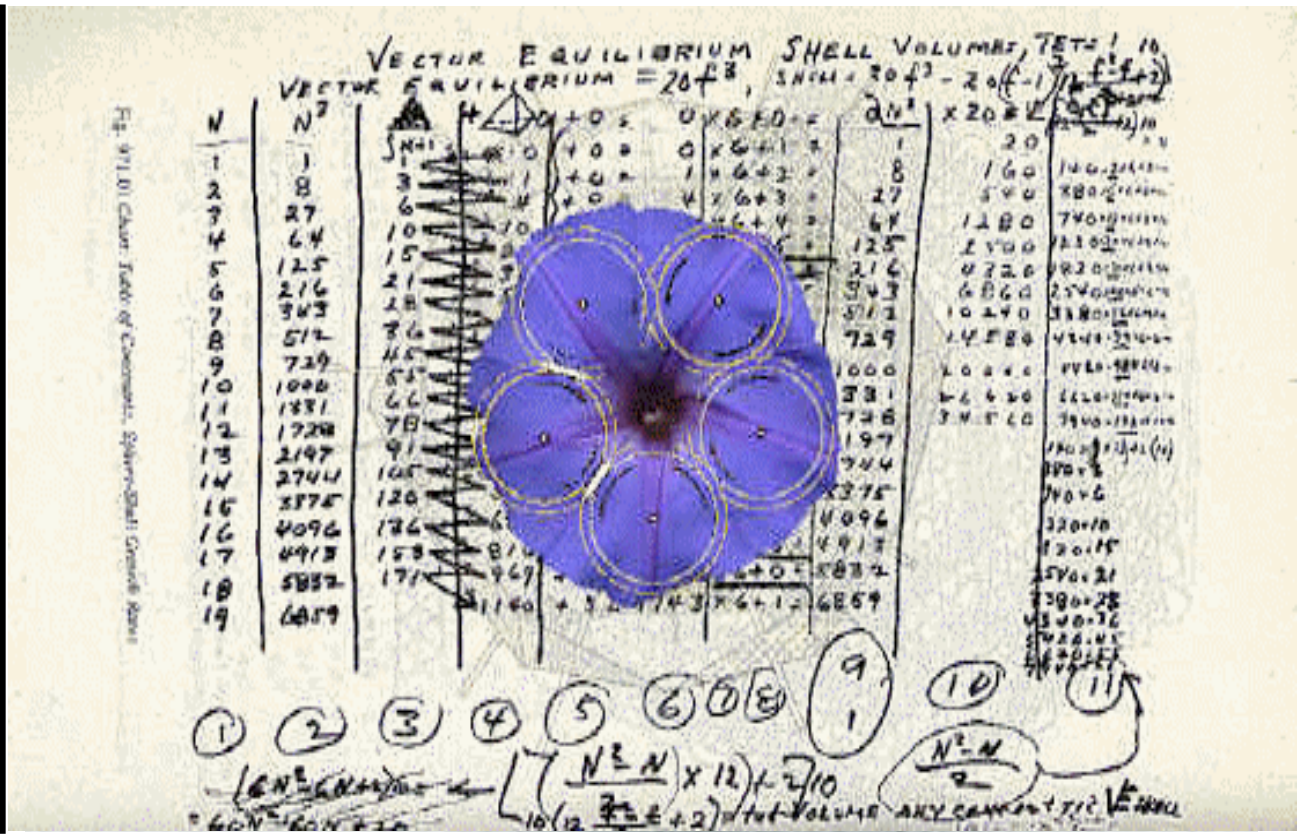
Semester Thesis

INSTITUTE OF COMPUTATIONAL SCIENCE



Synergetics: The Master Equation

Simulations of complex systems described by the Master Equation.

Synergetics deals with complex systems composed of many individual parts that interact and are able to form spatial, temporal or functional structures by means of self-organization.

The field of Synergetic was first introduced in 1969 by Hermann Haken and earlier in a related design framework by Buckminster Fuller. It receives renewed attention in in describing emerging phenomena in social and life sciences.

In this project, we will develop a generalized framework for the evolution of such complex systems using the master equation. The classical stochastic solution of the Master equation (as introduced by Gillespie) will be enhanced in order to account for spatially varying populations of interacting individuals. Hybrid computations involving deterministic and stochastic descriptions will be investigated.

In particular, phenomena that can be formulated as reaction-diffusion-coaglation systems will be considered, with examples from life sciences and social sciences such as bacterial colonies and competing societies. The optimization of the interaction rules of certain individuals in order to achieve specific macroscale behavior will be investigated.

PREREQUISITES

Programming experience
Multiscaling, Stochastics or Probability classes
Independent worker

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CSE LAB

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In the CSE Lab we combine computational methods, computer science tools, and domain specific knowledge to solve scientific and Engineering Problems in areas such as Fluid Mechanics, Nanotechnology and Life Sciences. The core computational competences of our group are in particle methods and in stochastic optimization techniques. Motivated by challenges in application fields, we focus on identifying the common elements among computational techniques and on formulating common methodological, algorithmic and software structures that facilitate their further development.