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The Cahn-Hilliard equation and the origin of life

The Cahn–Hilliard model with reaction terms can lead to situations in which no coarsening is taking place and, in contrast, growth and division of droplets occur which all do not grow larger than a certain size. This phenomenon has been suggested as a model for protocells, and a model based on the modified Cahn–Hilliard equation has been formulated. We introduce this equation and show the existence and uniqueness of solutions. Then asymptotic expansions are used to identify a sharp interface limit using a scaling of the reaction term, which becomes singular when the interfacial thickness tends to zero.

The sharp interface limit is a nonlocal geometric evolution equation of Mullins-Sekerka type. We will study the stability of stationary solutions and identify parameters which lead to instabilities. It will turn out that these instabilities can lead to topology changes which can result in the splitting of so-called protocells.
In addition, we present numerical simulations which will show that the reaction terms lead to diverse phenomena such as growth and division of droplets in the obtained solutions, as well as the formation of shell-like structures.
This supports claims in biophysics which state that featureless aggregates of abiotic matter may evolve and form protocells which can be the basis for systems that gain the structure and functions necessary to fulfill the criteria of life.