Energy and implicit discretization of density-dependent Keller-Segel type equations

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Chemotaxis, the movement of cells or organisms in response to chemical gradients, is a phenomenon that can be observed in many biological species, from bacteria to tumor cells. We collaborate with a team of cancer biologists at INSERM (Paris) that carried out three-dimensional biological experiments to understand the reciprocal interactions between breast cancer cells and adypocites. Their experiments show a collection of inhomogeneous spheroidal spots, i.e. spatially inhomogeneous aggregates of cells. Changing some important parameters, such us the initial number of cells or their invasiveness, several different patterns can be observed.
Our aim is to explore the possibility to replicate the patterning behaviors observed experimentally with two different variants of the original Keller-Segel system. Our models take into account volume effects that prevent overcrowding of cells, thus excluding blow-up of solutions and enabling a better understanding of the evolution in time of the solutions. Due to the presence of nonlinear terms, the models we study are mainly analytically untractable and thus suitable numerical methods are required. We propose a conservative, semi-implicit in time, finite difference scheme which maintains the nonnegativity of solutions, preserves the conservation of the total mass at the discrete level and the dissipation of the energy of the system at both the semi-discrete and discrete level.

Références

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