Finite-volume methods for cross-diffusion systems. Part I: ideas, techniques, proofs. Part II: examples, applications, extensions

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Abstract

Many applications in physics and biology, like segregation of population species, fluid mixtures, and tumor growth, can be described on the macroscopic level by so-called cross-diffusion systems, which are systems of strongly coupled parabolic equations. Often, the diffusion matrix of these models is neither symmetric nor positive definite, but the formulation in terms of entropy variables yields a positive semidefinite mobility matrix. This formulation reveals a formal gradient-flow or entropy structure. The talks introduce to the numerical approximation of such cross-diffusion systems using implicit Euler finite-volume methods, with a focus on structure-preserving numerical schemes. The first talk explains a discrete boundedness-by-entropy method, which allows for discrete L^∞ bounds and entropy-preserving discretizations, and presents the numerical analysis as well as the convergence of the scheme. The second talk gives some examples from applications as well as some extensions to temporal higher-order schemes.