Viscoelastic phase separation: Modelling & Structure-preserving discretisation

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In the context of binary phase separation dynamic symmetry of both phases, i.e. similar relaxation time scales, plays a crucial role in modelling. The generally accepted model is an incompressible Cahn-Hilliard-Navier-Stokes system for the evolution of the volume fraction and the velocity. In viscoelastic phase separation, this dynamic symmetry is broken, since polymer chains and solvent particles have effects on completely different time scales. To accommodate these asymmetrical effects, the model is extended by additional equations. On one hand, the viscoelastic effects arising from chain dynamics are modeled using the Peterlin model for the conformation tensor. On the other hand, mixing effects between solvent and chains are captured through a nonlinearly coupled advection-reaction-diffusion equation, augmenting the Cahn-Hilliard equation.
In the absence of the conformation tensor, we employ a structure-preserving approximation using conforming finite elements both in space and time. This method is shown to accurately preserve essential thermodynamic quantities, such as conservation of mass and energy dissipation.
Theoretical findings are complemented by a convergence test and an illustrative example drawn from practical applications.

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