Numerical simulation of some viscoelastic fluids

Abstract

Numerical simulation of the Oldroyd-B type viscoelastic fluids is a very challenging problem. When the Weissenberg number, which represents the ratio of elasticity to viscosity, exceeds some limits, simulations done by standard methods break down exponentially fast in time. However, some approaches, such as the logarithm transformation technique can significantly improve the limits of the Weissenberg number until which the simulations stay stable. We should point out that the global existence of weak solutions for the Oldroyd-B model is still open. Let us note that in the evolution equation of the elastic stress tensor the terms describing diffusive effects are typically neglected in the modelling due to their smallness. However, when keeping these diffusive terms in the constitutive law the global existence of weak solutions in two-space dimension can been shown.

The main part of our work is devoted to the stability study of the Oldroyd-B viscoelastic models. Firstly, we will show that the free energy of the diffusive Oldroyd-B model as well as its logarithm transformation are dissipative in time. Further, we will develop free energy dissipative schemes based on the characteristic finite element and finite difference framework. In addition, the global linear stability analysis of the diffusive Oldroyd-B model will also be discussed.