129i An Exponential Mapping for the Conformation Tensor for Flow of Viscoelastic Fluids; Application in Turbulent Channels

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The conformation tensor is a quantity that describes the internal microstructure of polymer molecules in a continuum level and is usually being used as the primary variable in viscoelastic flow calculations. Its connection with the polymer stress is known and its main property is that is a positive definite, second order, tensor. Unless special care is taken, the conformation tensor may lose this property resulting to instabilities during the calculations and finally either to break-up of the simulations or to non-physical results. This situation is greatly intensified under turbulent conditions. In order to resolve these problems we have expressed the conformation tensor, c, as the exponential of another tensor a, c=exp(a). We have derived the evolution equations for both the tensor a and its eigenvalues and we solve for a instead of c. By construction, the positive definite property of c is always preserved since its eigenvalues are the exponential of the eigenvalues of a (which can be either positive or negative). The method is illustrated for viscoelastic turbulent channel flow. The Direct Numerical Simulations (DNS) are being performed using spectral spatial approximations and a stabilizing artificial diffusion in the viscoelastic constitutive model. The additional diffusion term is needed to smooth the solution to be resolvable with the mesh size used due to the very fine scales that are being created in chaotic flow fields. The Finite-Elasticity Non-Linear Elastic Dumbbell model with the Peterlin approximation (FENE-P) is used to represent the effect of polymer molecules in solution. We will offer a comparison of the results, for exactly the same flow, viscoelastic and numerical parameters, using the old and the new formulation of the constitutive model in terms of the conformation tensor c, and the a tensor, respectively.