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ANISOTROPIC MESH ADAPTATION FOR VISCOELASTIC FLUID FLOWS

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The simulation of viscoelastic fluid flows is plagued by the high Weissenberg number problem. Most numerical methods do not converge in the non-linear iteration process at high Weissenberg numbers w.r.t. the mesh size. Part of the problem comes from limitations in the constitutive models, e.g., the Oldroyd-B model that assumes the molecules to be linear elastic. In a finite element analysis, numeric instabilities may emanate from the convective nature of the constitutive model and the violation of compatibility requirements between the interpolation spaces of the unknowns. So-called logarithmic conformation (log-conf) reformulations enabled the computation of flows at higher Weissenberg numbers and alleviated the limitation of the mesh size. Adaptive re-meshing techniques are in common use in modern CFD codes. Given an initial mesh, its corresponding finite-element solution is computed. Then some a posteriori error model is used to generate a completely new mesh, and a new solution is computed. This process is repeated until some error level is met. Anisotropic adaptive methods have the advantage that they can generate meshes with fewer elements of comparable accuracy compared to hand-crafted or split-refined meshes. Log-conf formulations provide the necessary tool to explore adaptive methods for viscoelastic flows. We use the general framework by Rangarajan et al. [1] to drive a metric-based anisotropic adaptation. This framework is interfaced with our recently developed stabilized method in the family of variational multiscale methods for a log-conf reformulation [2].

REFERENCES

[1] A. Rangarajan, G. May. Metric Construction for Error Control of Finite Element Solutions, AIAA paper 2019-3058.

[2] S. Wittschieber, L. Demkowicz, M. Behr. Stabilized finite element methods for a fully-implicit logarithmic reformulation of the Oldroyd-B constitutive law. arXiv:2112.06829