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Symmetric-hyperbolic conservation laws modelling viscoelastic flows

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Many equations have been proposed to model flows with a viscoelastic behaviour, for various applications (polymer suspensions, turbulent fluids averaged in time/space…). As regards viscoelastic models for fluids, with stress relaxation, seminal equations have been proposed by Maxwell in 1867. The Upper-Convected Maxwell equations are useful for one-dimensional flows in particular. But the usability of such viscoelastic fluid systems for multi-dimensional flows remains limited, as shown by numerous numerical simulations that do not converge when the discretization parameters are refined beyond a critical value for the relaxation-time of the stress. As a remedy, we propose to consider a system of conservation laws with algebraic source terms (balance laws) to model viscoelastic flows. The system is symmetric-hyperbolic. It unifies hardly-elastic fluid models with hardly-compressible solid models, similarly to the famous K-BKZ integral viscoelastic models, but in a more versatile (purely differential) way based on an evolution equation for the anelasticity metric tensor. The new system can be manipulated for various applications of the viscoelastic flow concept in environmental hydraulics (shallow-water flows) or materials engineering (non-isothermal flows).

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References

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