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Origin and nature of the high Weissenberg number singularity and its removal via a new Boltzmann-type molecular non-Hookean model[1]
RHO SHIN MYONG, Gyeongsang National University — The Maxwell-Oldroyd model in viscoelastic fluids is known to break down at frustratingly low values of the Weissenberg number. In this work, the origin of the mathematical singularity was shown to be the unbalanced treatment between two open kinematic and interacting terms in the Maxwell-Oldroyd model. Under severe extension, the stress-strain coupling term of quadratic nature will grow far faster than the strain rate term, resulting in a blow-up singularity from an imbalance with the first-order linear interacting term and eventually numerical instability associated with unstable saddle topology. On the other hand, the singularity arising from unbalanced treatment does not occur in the case of velocity shear and contracting flows, since the second-order interaction effects are cancelled under the constraint of asymptotic behavior. In order to remove the singularity, a new theoretical non-Hookean spring force model from the Boltzmann-type molecular-level description based on the concept of gain and loss was proposed. The new second-order implicit model with a hyperbolic sine factor was then shown to be well-posed for all regimes, completely removing the high Weissenberg number singularity.

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