Regular and chaotic orientational and rheological behavior of liquid crystals

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The rheological properties of nematic liquid crystalls are strongly affected by the dynamic behavior of the alignment of the particles. Dramatic nonlinear effects are observed in lyotropic and in polymeric liquid crystals where the orientational relaxation time is large. Starting from a closed nonlinear inhomogeneous relaxation equation for the 5 components of the alignment tensor [1] which, in turn, can be inferred from a generalized Fokker-Planck equation [2], it has recently been demonstrated that the rather complex orientation behavior of ”tumbling” nematics can even be chaotic [3] in a certain range of the relevant control variables, viz. shear rate and tumbling parameter. A similar conclusion was reached in [4] where 65 moments were used in a solution of the Fokker-Planck equation. In this talk, the orientational behavior and the rheological consequences, in particular the shear stress and the normal stress differences are computed and discussed for such a nematic. Long-time averages are evaluated both for imposed constant shear rate and constant shear stress. The time response of the shear stress to step-like and ramp-like shear rates as well as to reversal of the shear rate are analyzed in the regular and in the irregular, i.e. chaotic regimes.

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