The dynamics of nematic liquids in linear flows: molecular theory and averaged descriptions

M. Gregory Forest
University of North Carolina at Chapel Hill, USA
e-mail `forest@amath.unc.edu`

Qi Wang
Florida State University, USA
e-mail `wang@math.fsu.edu`

Ruhai Zhou
University of North Carolina at Chapel Hill, USA
e-mail `ruhai@amath.unc.edu`

Nematic polymers are pervasive in biological and synthetic soft matter. The Tobacco Mosaic Virus and spider silk are two natural examples of macromolecules which exhibit nematic ordering, yet whose behavior is dynamically more complex than small-molecule liquid crystals. We present a hierarchy of models for nematic polymers: Leslie-Ericksen theory, second-moment tensor models of Landau-deGennes type, and kinetic theory of Doi and Hess. For bulk dynamics of homogeneous nematic liquids in linear flows (e.g., simple shear), the orientational dynamics decouples. The models listed above then reduce to two, five, and infinite-dimensional dynamical systems for the orientational response to linear flow. We report theory, analysis, and simulation of the shear flow problem for nematic polymers from each of these scales of description. Contact with related discoveries, especially the seminal contributions of Italian colleagues (Greco, Maffettone, Marrucci, Virga and others), will be emphasized.

Presented by M. Gregory Forest