Is a uniaxial approximation for polymeric fluids suitable for elastic turbulence?

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Keywords: Elastic turbulence, polymeric fluids, uniaxial model, Elastoinertial turbulence

Elastic turbulence is an intriguing flow phenomenon that occurs in polymeric fluids, where despite negligible inertia, elastic instabilities drive the fluid into a highly chaotic flow state. Polymeric fluids may also sustain inertial turbulence, albeit with significantly modified flow statistics and scaling laws. Modeling polymeric fluids remains a challenge, where the usual approach entails numerically solving coupled fluid and polymer stress transport equations, where polymers are modeled as an ensemble-averaged conformation tensor. We investigate whether a simpler approach, called the "uniaxial model" where the conformation tensor is reduced to a lower-dimensional end-to-end vector, can suffice for certain flow configurations. After all, in its stretched state, a polymer may well be approximated as a slender, linear object. Apart from numerical simplicity, the uniaxial model also bears similarities with magnetohydrodynamics, making for interesting parallels. We quantify the extent to which such an approximation works, and highlight its limits vis-à-vis the flow structures that cause it to breakdown.