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Multi-scale analysis of polymer-diluted turbulent flow using a new elastic dumbbell model with incorporation of variable non-affinity.
KIYOSI HORIUTI, SHOTARO SAYAMA, Tokyo Institute of Technology — We consider turbulent flows diluted with the polymers. The polymer chains are modeled as elastic dumbbells and represented by Brownian dynamics. The motion of solvent fluid is pursued by DNS. Affinity in the motion of the bead-spring configuration with the fluid surrounding the dumbbells is commonly assumed, but it results in emergence of Elasto-inertial turbulence (EIT) regime. When the polymers are highly stretched, molecular motions may not precisely correspond to the macroscopic deformation (de Gennes 1986). We develop a new dumbbell model in which the affine constraint is removed and non-affinity is introduced by allowing slippage of the dumbbells against the solvent. This is done by adopting the lower-convective derivative in addition to the upper-convective derivative in the governing equation for the motion of the dumbbells. We conduct its assessment in the forced homogeneous isotropic turbulence. It is shown that the dumbbells obtained from the case with complete affinity are rotated and converted to the alignment of the dumbbells in the complete non-affine case, and vice versa. This alteration of configurations is repeated quasi-periodically with the intervals comparable to the relaxation time. The largest stretching of the dumbbells and elastic energy production are achieved in the complete non-affine dumbbells. Occurrence of EIT is eliminated and de Gennes hypothesis is justified.

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