Flow Instabilities & Turbulence in Viscoelastic Fluids

Workshop: July 19 - 23 2010, Leiden, The Netherlands

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The images show four stages of mixing of a passive dye by purely elastic turbulence.

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Elastic instabilities and efficient microfluidic rectifiers

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Abstract

In this talk we discuss a new type of microfluidic rectifier, with hyperbolic shape, which operates efficiently under creeping flow conditions using viscoelastic fluids. At low flow rates the pressure drop between the inlet and outlet ports of the microchannel is similar for both flow directions, so the diodicity is low. However, above a critical flow rate (or Deborah number), the flow patterns are markedly different in both flow directions, leading to quite different behaviour in terms of pressure drop in the forward and backward flow directions for the same imposed flow rate. Using flow visualization and micro-particle image velocimetry we show that the enhanced pressure drop in the forward direction (along a series of hyperbolic contractions and abrupt expansions) is due to the onset of elastic instabilities that develop in such a highly extensional flow, leading to a complex unsteady flow. We investigate the effects of the shape of the geometry and the depth of the microchannels on the measured diodicity using different types of viscoelastic fluids, and compare the results with those for a Newtonian fluid (distilled water).