Instability of a viscoelastic wall jet: when a small amount of polymer destabilizes the flow

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We use high-speed digital Schlieren imaging to visualize the evolution of Lagrangian flow structures in a thin planar jet of a dilute aqueous polymer solution entering a quiescent bath of its Newtonian solvent. Visualization of these structures is impossible with the naked eye due to the similar densities of the polymer solution and water. The small density difference, however, provides sufficient refractive index difference for Schlieren imaging. A glass wall is placed behind the jet imposing no-slip boundary condition, which generates a wall jet. The transparency of the glass wall allows visualization of the flow as it moves downstream on the glass surface. The left image shows a water jet at a Reynolds number of 1000, the right image shows a viscoelastic jet with only 75 ppm of polyethylene oxide (average molecular weight of 8,000,000 g/mol) at the same Reynolds number. A shear layer instability develops in the Newtonian wall jet. In the viscoelastic wall jet, the instability is amplified and the jet becomes turbulent downstream. These images show how the addition of a small amount of polymer to the solution can significantly destabilize the flow. The jet has an aspect ratio of 10 at the nozzle; and the planar jet has a width of 4 mm and a thickness of 0.4 mm. The characteristic shear rate is 2000 s^{-1} and the Weissenberg number of the polymeric jet is 42.