Title: Computational study of dynamics and transport in vortex-dipole flows

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Abstract:
The dynamics and transport in vortex-dipole flows are studied numerically using a high order finite difference method and the Lamb Dipole as the dipole unit. Material points are sampled in the dipole and move at the flow velocity to visualize the dipole flow transport. The computation starts with one dipole translating in free space whose vorticity, streamlines, kinematic pressure, and the sampled material points are plotted at a sequence of times. Later multiple dipoles interactions are considered. The results have two aspects. First, for two dipoles moving in an opposite direction towards each other, a slight mass transport is observed and it relates to the strain rate field of the flow. For two dipoles moving in the same direction, head-to-toe, the dipole behind gets entrained into the dipole in front, forming a single larger dipole in the end. Second, dynamics of multiple dipoles interactions can be decomposed into a combination of fundamental structures resulted from two dipole interactions.

Keywords: Navier-Stokes; Lamb dipole; strain rate; principle axes; vorticity; viscous flow