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Particles and Fields in Binary- and Ternary-Fluid Turbulence

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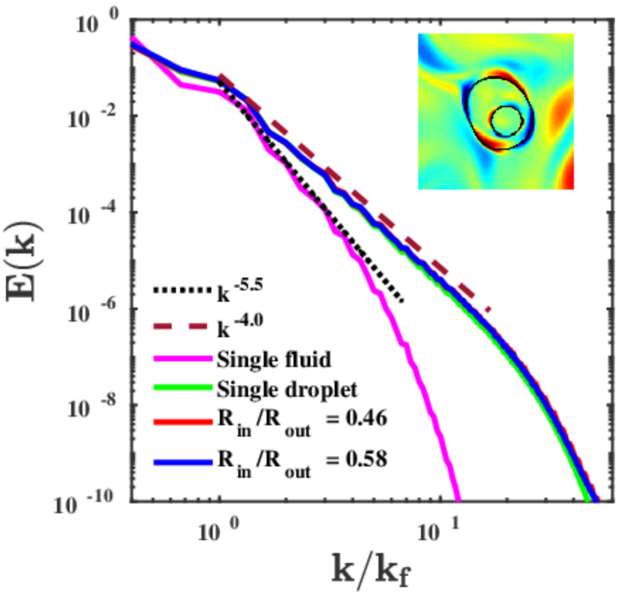
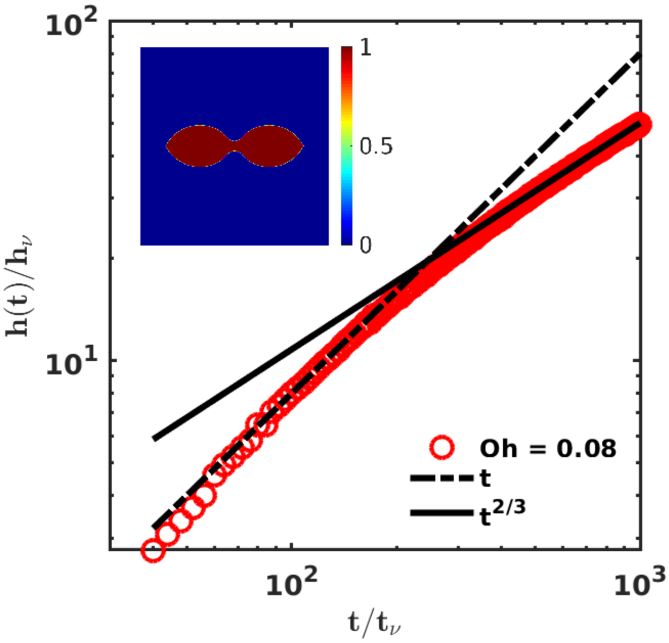
There are several examples of binary- and ternary-fluid flows and of turbulence in such flows. It is shown that the Cahn-Hilliard-Navier-Stokes (CHNS) equations, for such binary and ternary fluids, provide a natural theoretical framework for studying the statistical properties of such turbulence and also the statistical properties of particles advected by these binary- and ternary-fluid flows. Illustrative results from our recent direct numerical simulations of such flows will be presented.

Earlier work from our group [1-5] has used the CHNS equations to investigate (a) multifractal droplet dynamics in a turbulent flow [5], (b) turbulence-induced coarsening arrest in a binary-fluid mixture [3], and (c) the spatiotemporal evolution of antibubbles [1]; and we have also developed regularity criteria for solutions of the three-dimensional CHNS equations [2,4]. After brief introductions to these studies, we will describe our CHNS-based work on ternary-fluid mixtures in which we have recently examined (a) encapsulated compound droplet dynamics [Fig. 1], (b) lens mergers [Fig. 2].



(Fig. 1) Kinetic energy sepctra for a single fluid (magenta line), fluid with a single droplet (green line) and encapsulated compound droplets with different radius ratios (red line and blue line). The insets show pseudocolor plots of the vorticity field with phase-field contours superimposed on them.



(Fig. 2) Time series plot of the bridge width during the coalescence dynamics for Ohnesorge number, Oh = 0.08. The crossover between the viscous and intertial scales are represented by the scaling exponents 1 (black dotted line) and 2/3 (black line), respectively. The inset shows the pseudocolor plot of the phase field during the coalescence.

References:

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