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The development of nonlinear instability waves in two-fluid shear flows with complex interfacial topology LAWRENCE CHEUNG, TAMER ZAKI, Imperial College London — We present a nonlinear stability formulation for laminar, two-fluid shear flows which undergo changes in interface topology. The formulation combines the nonlinear Parabolized Stability Equations with a scalar-based interface capturing scheme. In doing so, this approach retains the flexibility and insight of instability-wave based methods, and accurately accounts for the nonlinear physical mechanisms responsible for complex deformations to the interface. This new approach is used to simulate the nonlinear evolution of instability waves in spatial, two-phase mixing layers with density and viscosity stratification. We demonstrate that the dynamics of the disturbance waves are well-predicted, by comparing our results to direct Navier-Stokes simulations. The new method accurately captures the formation of large-scale structures such as Kelvin-Helmholtz vortex rolls and liquid ligaments in two and three dimensions. Using this formulation, we also illustrate the importance of the mean flow distortion, nonlinear interactions, and finite amplitude effects to the development of the two-fluid structures. In addition to accuracy, the computational efficiency of our method is compared to direct Navier-Stokes simulations.

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