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Mixing dynamics and pattern formation around flow stagnation points

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We study the mixing of two reactive fluids in the presence of convective instabilities. Such system is characterized by the formation of unique porosity patterns and mixing dynamics linked to the evolution of vortices and stagnation points. Around them, the fluid-fluid interface is stretched and compressed, which enhances mixing and triggers chemical reactions, and the system can be analyzed using fluid deformation model.

We consider velocity fields generated by a double gyre synthetic velocity field and Rayleigh-Bénard and Rayleigh-Taylor instabilities. The different flow structures can be visualized by the strain rate and the finite time Lyapunov exponents. We show that the mixing enhancement given by the scalar dissipation rate is controlled by the equilibrium between interface compression and diffusion, which depends on the velocity field configuration. Furthermore, we establish a quantitative relation between the mixing rate and the evolution of the potential energy of the fluid when convection is driven by density instabilities.