The Mixing Dynamics of the Blast-Driven Instability

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The fluid mixing caused by variable-density instabilities is important in a wide variety of scenarios from ocean mixing and astrophysical phenomena to nuclear fusion techniques and atomic weapons. This work explores the mixing resulting from a specific instability known as the Blast-Driven Instability (BDI). Using high speed experimental techniques, the first fully time-resolved observations of the BDI are made [1]. These observations have been used to test common mixing models (RANS and LES) in a "digital-twin" simulation [2]. The experimental data is used in conjunction with the simulation results to explore the BDI's sensitivity to two key governing parameters: the blast Mach number, M, and normalized density ratio, A. How changes in these governing parameters create qualitative and quantitative changes in the BDI's behavior is explored extensively. Finally, various scaling attempts are investigated in an attempt to decipher how the mixing induced by the BDI can be explicitly linked to these parameters.

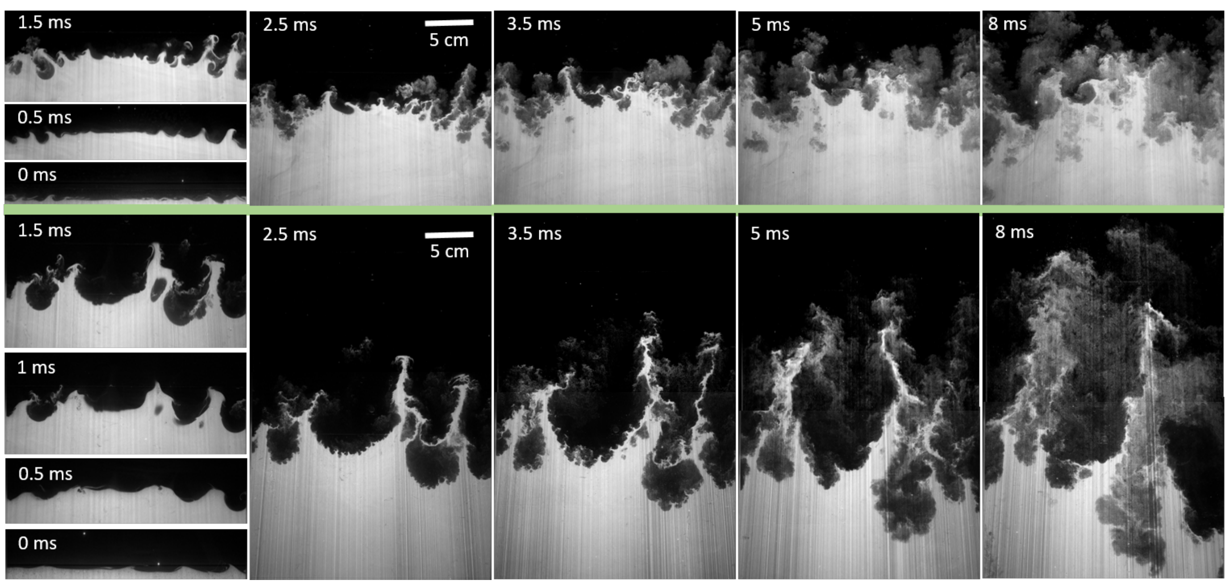

Figure 1. Experiments with $M = 1.55$ and different A, with the two cases separated by the green bars. Top row) $A = 0.68$ and bottom row) $A = 0.95$. In all cases the IC prior to blast impact is shown at $t = 0$ ms. The different morphological development in each highlights some of the effects caused by varying the driving parameters.

References

1. B. Musci, S. Petter, G. Pathikonda, B. Ochs & D. Ranjan, Supernova hydrodynamics: A lab-scale study of the blast-driven instability using high-speed diagnostics, *The Astrophysics Journal*, **896**, 2 (2020).
2. B. Musci, B. Olson, S. Petter, G. Pathikonda & D. Ranjan, Multifidelity validation of digital surrogates using variable-density turbulent mixing models, *Phys. Rev. Fluids*, **8**, 1 (2023).