Journal of Fluids Engineering

Guest Editorial

The 14th International Workshop on the Physics of Compressible Turbulent Mixing

The theoretical, numerical, and experimental study of compressible, variable-density, and incompressible turbulent mixing associated with Richtmyer–Meshkov (RM), Rayleigh–Taylor (RT), and Kelvin–Helmholtz (KH) instabilities is motivated by diverse applications in science and engineering including combustion and other chemically reacting flows, stratified geophysical flows, inertial confinement fusion (ICF), and astrophysical flows (supernovae, molecular clouds, and stellar interiors, for example). The study of these instabilities and associated mixing is particularly challenging due to the fact that they involve multiple fluids (or materials), rather than single fluids. The Reynolds number becomes very large in many of these applications, and the instabilities rapidly lead to turbulent mixing. In the case of ICF, which is currently an intensively studied approach to controlled thermonuclear fusion (and a potential alternative to magnetic fusion): (1) these instabilities lead to growth of perturbations on the interfaces within the fuel capsules; (2) the perturbations grow into the nonlinear regime by mode-coupling, eventually resulting in the mixing of materials; and (3) the material mixing inhibits or otherwise reduces the efficiency of thermonuclear burning of the fuel.

There are ongoing research efforts in the U.S., UK, France, Russia, China, and in other countries to design improved shock tube experiments and experiments using novel apparatuses and advanced diagnostics in order to further elucidate the physics of RM, RT, and KH instabilities (as well as combinations of these instabilities) and better understand turbulent mixing across material interfaces. There are, however, a number of difficulties associated with experiments, including: separating the fluids initially, the design and interpretation of appropriate diagnostics, and the inability to measure certain quantities of interest either because of their intrinsic nature (e.g., vorticity) or because of limitations in the experimental configurations or resolution of diagnostics. Computational, theoretical, and modeling studies have been conducted in conjunction with experiments to complement the data obtained from the experiments, aid in the design and interpretation of experimental results, develop reduced model descriptions (such as Reynolds-averaged and buoyancy–drag models), and validate numerical methods and codes by comparisons to experimental data and theoretical results. The numerical simulation techniques applied to these hydrodynamic instability and turbulent mixing problems comprise the full spectrum of approaches used to study turbulent flows: direct numerical simulation (DNS), large-eddy simulation (LES), monotone or implicit LES (MILES or ILES), and Reynolds-averaged simulation.

The 14th International Workshop on the Physics of Compressible Turbulent Mixing (IWPCTM14) was organized by the Lawrence Livermore National Laboratory and held in San Francisco, CA (Aug. 31–Sept. 5, 2014), with additional co-sponsorship from the Commissariat à l'Énergie Atomique et aux Énergies Alternatives (France) and the Atomic Weapons Establishment (UK). The conference was attended by a large contingent of scientists from the U.S., UK, France, China, Japan, Russia, and Israel. Experimental, theoretical, and computational studies of mixing processes applied to a wide range of problems were discussed at the workshop. The IWPCTM14 provided an excellent opportunity for an international group of delegates from national laboratories, institutes, and universities to review state-of-the-art research on turbulent mixing and to discuss future research directions in this field (for more information on this series of biennial workshops and for proceedings from previous workshops, see the IWPCTM website).[1]

This special section issue of the *ASME Journal of Fluids Engineering* publishes peer-reviewed experimental, computational, and theoretical research papers based on presentations given at the IWPCTM14. Wilson et al. described the experimental results from the Los Alamos National Laboratory Vertical Shock Tube Facility that examined the effect of initial conditions and Mach number on RM instability. Shimony et al. combined the new numerical simulations and statistical modeling to obtain insights into the effect of long-wavelength initial conditions on the development of KH instability observed in previous OMEGA laser experiments. Annamalai et al. used the numerical simulations to investigate the properties of the multiphase instability resulting from the explosive dispersal of a dense core of solid particles. Computational studies also focused on Reynolds-averaged modeling and LES of unstable turbulence due to RT and RM instabilities. Gréa et al. discussed the challenges facing mixing models for capturing flow transients using unstably stratified homogeneous turbulence as a test problem. Zhou and Thornber gave an overview of various methods for determining the effective eddy viscosity in ILES.

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[1]http://www.iwpctm.org