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Guest Editorial

Special Section on the 15th International Workshop on the Physics of Compressible Turbulent Mixing

The study of compressible turbulent mixing associated with Richtmyer–Meshkov (RM), Rayleigh–Taylor, and Kelvin–Helmholtz instabilities is motivated by applications in science and engineering including inertial confinement fusion, supersonic combustion, detonation, instability of collapsing gas bubbles, stratified flows in geophysical applications, chemical engineering, core-collapse supernovae, and molecular clouds. Further, the interaction of shock waves with materials is also of interest in biomedical applications such as fragmentation of cancer cells during shock-wave chemotherapy and cavitation-damage to human tissues during lithotripsy. In many of these applications the Reynolds number is very high and the instabilities rapidly lead to turbulent mixing. In the case of inertial confinement fusion, which is regarded as a promising approach to controlled thermonuclear fusion: (1) these instabilities lead to the growth of perturbations on the interfaces within the capsules; (2) the perturbations become nonlinear, transition to turbulence, enhancing material mixing; and (3) material mixing inhibits thermonuclear burning of the fuel.

A complete understanding of these fundamental instabilities is extremely challenging, given that the flows under consideration may include: multiple compressible species, shock waves, large variations in density, high geometrical convergence, and extremely small time scales. In laser-driven experiments, instability growth may be further modified by real gas effects, ablation, radiation, magnetic fields, conduction, viscous dissipation, and additional perturbation seeds such as drive nonuniformity. Experimentalists must develop innovative approaches to designing experiments with repeatable and characterizable flow conditions, incorporating advanced diagnostics which can extract quantitative, time-resolved data. Numericists must design robust numerical schemes capable of accurately simulating highly compressible, multispecies or multiphase flows with turbulent structures ranging in size from the mixing layer width to the Kolmogorov scale. Theoreticians must combine physical insight with experimental and numerical data to develop models which address the nonlinearities in the governing equations, or enable a reduction in problem dimensionality. These models may then predict the details of instability growth in new configurations or give insight into the fundamental physics of instability development. Despite these many challenges, great advances are being made in the understanding of these instability-driven turbulent flows. These advances are the focus of the International Workshop of the Physics of Compressible Turbulent Mixing (IWPCTM).

The IWPCTM has been held biannually since the first meeting in 1988. The 15th International Workshop on the Physics of Compressible Turbulent Mixing (IWPCTM15) was organized in Australia by the University of Sydney (July 10–15). It brought together more than 70 scientists from a range of countries including the UK, USA, Russia, France, and China. The IWPCTM15 offered an excellent opportunity to an international group of delegates from national laboratories, institutes, and universities to review the state-of-the-art research on compressible turbulent mixing and to stimulate the discussion of future research in this field (for more information on this series of workshops and for proceedings from previous workshops, see the IWPCTM website).[1] The conference was sponsored by the Commissariat à l'Energie Atomique (CEA, Gif-sur-Yvette, France), the Atomic Weapons Establishment (AWE, Reading, UK), the New South Wales Office of the Chief Scientist and Engineer, and the University of Sydney.

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 IWPCTM15. Bakhsh and Samtaney report on the linear stability of the cylindrically converging MHD RM instability, identifying a suppression mechanism which reduces the growth rate in proportion to the strength of the magnetic field. Gibbons et al. detailed a numerical study of laser ignition in hypersonic scramjets, focusing on the impact of the plasma and shock wave on resultant mixing. Resnyansky examines the interaction of solid and gas phases during shock compression of a porous material via a mesomechanical hydrocode model, demonstrating that interstitial gas properties may provide a substantial variation in time of arrival of the shock wave. Subramaniam et al. presented a new very high-order numerical method for continuum elastic–plastic multimaterial flows, validated for one- and two-dimensional test cases including an RM instability between copper and aluminum. Boureima et al. reported on the turbulent kinetic energy, anisotropy, density self-correlation, and atomic mixing in computations of spherical RM instability. Finally, Shimony et al. examined the impact of density ratio on the mixing and entrainment, and the subsequent measured asymptotic growth in two- and three-dimensions as a function of an effective Atwood number.

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

