The 13th International Workshop on the Physics of Compressible Turbulent Mixing

By Dimitris Drikakis (Cranfield University, UK)
David L. Youngs and Robin J. R. Williams (Atomic Weapons Establishment, UK)
Oleg Schilling (Lawrence Livermore National Laboratory, USA)
Stuart Dalziel (University of Cambridge, UK)

The study of compressible 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 supersonic combustion, detonation, instability of collapsing gas bubbles, stratified flows in geophysical applications, chemical engineering, inertial confinement fusion (ICF), 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 ICF, 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) perturbations grow into the nonlinear regime by mode-coupling and eventually cause mixing of materials, and; (3) material mixing inhibits thermonuclear burning of the fuel.

There are ongoing research efforts at research centers in the USA, UK, France, Russia and China to design increasingly better shock tube experiments in order to further elucidate RM instability and better understand turbulent mixing across material interfaces. Novel experiments are also being performed to further investigate RT and KH instabilities, as well as combinations of these instabilities. There are, however, a number of difficulties associated with experiments, including: separating the initial gas regions; the interpretation of visualization images and challenges with diagnostics; and the inability to measure certain quantities of interest either because of their intrinsic nature (e.g., vorticity) or because of practical limitations in the experimental configurations. Computational, theoretical and modeling studies have been widely conducted in parallel with experiments to complement the data obtained from the experiments, help design and interpret results from experiments, develop reduced model descriptions (such as Reynolds-averaged and buoyancy–drag models), and validate numerical methods and codes by comparisons to experimental data. Numerical simulation techniques applied to these instability and mixing problems include direct numerical simulation (DNS), large-eddy simulation (LES), and monotone or implicit LES (MILES or ILES).

The 13th International Workshop on the Physics of Compressible Turbulent Mixing (IWPCTM13) was organized in the UK by Cranfield University at Woburn Abbey (15–20 July). The conference was co-hosted by the Atomic Weapons Establishment, with additional sponsorship from the Commissariat à l'Énergie Atomique et aux Énergies Alternatives, Los Alamos National Laboratory and Lawrence Livermore National Laboratory. The conference was attended by more than 70 scientists from a range of countries including the UK, USA, Russia, France, China, India and Spain. Experimental, theoretical and computational studies of mixing processes applied to a range of problems were discussed at the workshop. IWPCTM13 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 http://www.iwpctm.org). This special issue of the Journal of Fluids Engineering publishes peer-reviewed papers originally presented at the IWPCTM13.

Both experimental and computational papers are included. Experimental studies concern laser-driven hydrodynamic experiments; comparisons of tilted rocket-rig experiments with DNS, ILES and turbulence model predictions; and shock tube experiments. The computational papers concern LES and Reynolds-averaged turbulence modeling of RT and RM turbulent mixing, in fluids and solids. The results showed that significant progress has been made with regard to simulation and modeling techniques for turbulent mixing. However, further research is required to assess the accuracy and efficiency of different turbulence models against numerical simulation and experimental data in order to reduce the computational modeling uncertainty in applications such as ICF design. A review of phase separation, microchannel devices, is also presented. Finally, the papers discussed at the conference included applications of advanced computational methods and models in astrophysics.

The guest editors of this special issue would like to thank all of the authors for their efforts in preparing their contributions as well as all of the reviewers for their assistance in reviewing these papers. Finally, we would like to thank the Journal of Fluids Engineering Editor, Malcolm Andrews, the Editorial Office, Amber Grady-Fuller, and the Production Team at the American Society of Mechanical Engineers for their encouragement and assistance during the course of this special issue publication.