

## Preface

This volume contains the 2009 annual technical research briefs from postdoctoral fellows, Research Associates and senior visitors of the Center for Turbulence Research. The majority of CTR Postdoctoral Fellows are engaged in research using numerical simulations of multi-physics turbulent flows, including mixing and chemical reactions, multi-phase flows, subsonic and supersonic flows, aerodynamic noise, numerical analysis and subgrid scale model development. Most of CTR's support is provided by NASA's fundamental Aeronautics Program, and the U.S. Department of Energy's Advanced Simulation and Computing Program. This year CTR supported thirty resident postdoctoral fellows and research associates and five senior scholars.

The volume begins with two articles on supersonic jet noise which is a major concern for high speed aircraft. Prediction of jet noise was the primary driver for NASA's early support for the development of the Large Eddy Simulation (LES) technique in the Seventies. The exponential increase in computer power has made it possible to compute jet noise from realistic nozzle configurations and to explore noise mitigation strategies using numerical simulations. The second group of papers is concerned with hypersonic flow. Both air-breathing propulsion for hypersonic flight and non-equilibrium external aerodynamics for re-entry applications are considered. Full system simulation of a scramjet is the overarching problem of the Predictive Science Academic Alliance Program (PSAAP) at Stanford which is supported by the U.S. Department of Energy. At the core of this program is the development of probabilistic methods for uncertainty quantification in numerical predictions; several reports on this topic are included next. Turbulent combustion and the associated multi-phase flow problems continue to have a strong presence at CTR. Chemistry tabulation method has prevailed as the method of choice for high fidelity turbulent combustion simulations at CTR, and considerable effort is devoted to improve its predictive capabilities, for example, for flame structure, auto-ignition and pollutants. The next group of reports is concerned with turbulence model development for complex flows, including subgrid scale models for shock/turbulence interactions and multi-material turbulent mixing. Development of numerical methods for turbulent flow simulations are reported next. Included are methods for integration of different codes with different grid structures, methods for shock capturing in turbulent flows, two phase flows with high density ratios, proper boundary conditions and adjoint based methods for sensitivity analysis and error estimation. Minimization of numerical dissipation remains a key objective in the development of numerical methods for high fidelity turbulent flow computations at CTR. The last group of articles reports on the studies of flow physics using numerical simulations covering a broad range of applications ranging from bio-engineering to solar physics.

We thank Sara Bedin and Deborah Michael for their day to day management of CTR. The CTR roster for 2009 is provided in the Appendix. This volume is available at the CTR site on the worldwide web (<http://ctr.stanford.edu>).

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