HIERARCHICAL SIMULATION OF MULTI-SCALE INTERACTIONS IN TURBULENT REACTING FLOWS

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The impact on “large”-scale dynamical and turbulent processes in gas turbine combustors (such as vortex shedding and combustion instability due to acoustic-vortex interaction) of chemical kinetics and combustion heat release occurring at the “small”-scales is well established. Physics of interest include formation of pollutants (CO, NO and Soot) and models that can deal with these species are needed within a comprehensive simulation methodology that can also capture the dynamics of interaction between various scales of motion. Furthermore, current experimental effort on developing actively controlled (e.g., using embedded synthetic MEMS jets) fuel injectors to stabilize combustion in the lean limit introduces additional length and time scales that are geometrically controlled and therefore, cannot be modeled (and must be resolved). Recently, large-eddy simulation (LES) for turbulent reacting two-phase flow has been developed wherein the small-scale features are resolved in a finer grid embedded inside the LES grid. This highly parallel (but computationally demanding) method combines finite-volume LES with a Lattice Boltzmann (LB) approach at the micro (but continuum) scales (used to resolve geometrical features such as the embedded synthetic jets). This methodology also incorporates a Molecular Dynamics (MD) simulated library to estimate the inception of sub-nanometer soot particles within this multi-scale hierarchical simulation environment. Results obtained so far using this methodology will be discussed in this talk.