PPPL PRINCETON PLASMA PHYSICS LABORATORY

Colloquium

Simulation of Lean Premixed Turbulent Combustion

DR. JOHN B. BELL

Center for Computational Sciences and Engineering
Lawrence Berkeley National Laboratory, Berkeley, CA

Combustion is one of our oldest and most important technologies. It continues to provide most of the energy required for transportation and power generation. Recent concerns over U.S. dependence on imports of foreign oil, coupled with pollution and greenhouse gas emission issues, have generated significant interest in developing new fuel-flexible combustion systems that can employ alternative fuels such as hydrogen, ethanol or syngas. Effective utilization of these fuels requires combustion devices that can operate cleanly and efficiently over a broad range of fuels and fuel mixtures. Lean-premixed systems have the potential for meeting these requirements; they operate at high efficiency and have low NOx emissions due to reduced burnt gas temperatures. Although traditional scientific approaches based on theory and laboratory experiment have played essential roles in developing our current understanding of premixed combustion, they are unable to meet the challenges of designing fuel- flexible lean, premixed combustion devices. Computation, with its ability to deal with complexity and its unlimited access to data, has the potential for addressing these challenges. Realizing this potential requires the ability to perform high fidelity simulations of turbulent lean premixed flames under realistic conditions. Estimates of the computational cost of such simulations suggest that naive simulation approaches would be prohibitively expensive. In this talk, we examine the specialized mathematical structure of combustion problems and discuss approaches to simulation that exploit this structure. Using these ideas we can reduce computational cost by three to four orders of magnitude, making it possible to perform high- fidelity simulations of realistic laboratory flames. We will illustrate this methodology by considering several configurations to illustrate the methodology and discuss how this type of simulation is changing the way researchers study combustion.

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4:15 P.M. (Refreshments at 4:00 P.M.)

Lyman Spitzer Building, M. B. Gottlieb Auditorium