Weekly Seminar: Fall 2009

Date: October 16

Time: 11:00 AM

Location: Maryland Hall 110

Speaker: Alan Kerstein

Sandia National Laboratory

Title:*"Turbulent flames and other advected propagating fronts: Analysis, heuristics, speculation"*

Abstract

One of the most basic properties of a turbulent flame is its burning velocity U, defined as the volumetric rate of fuel consumption per unit projected area. It is difficult to model the parameter dependences of U, in part due to complicating influences such as thermal expansion and vessel geometry. A more fundamental difficulty is the lack of a mathematical framework for analyzing the ideal case of a dynamically passive, randomly advected front propagating at speed S. Progress toward the development of such a framework is reported, focusing on the weak-turbulence limit (S far exceeding the characteristic turbulence velocity V). Motivated by a surprising heuristic deduction supported by limited numerical evidence, a theoretical/computational study has been performed that confirms the heuristics and provides additional insight. A field-theoretic formulation has been solved using the replica method, yielding bounds on U that are shown to be nearly sharp by comparing them to high-precision computations. Moreover, the results indicate that U/S cannot depend solely on V/S, contrary to common belief. The functional form of the solution suggests a possible structure of a theory valid for large V/S, yet highlights the difficulty of such an extension. Nevertheless, the weak-turbulence results have direct relevance to optical, acoustic, and biological propagation phenomena, reflecting the fundamental nature of the problem that has been addressed. Beyond the weak limit, a heuristic model of the related problem of propagation through a non-advecting heterogeneous medium is described, and its applicability to combustion and to subsurface environmental flow is discussed.