A Wavelet/ILDM Method for Computational Combustion [1]

J. M. Powers[2], S. Paolucci[3], Y. Rastigejev[4], and S. Singh[5]
Department of Aerospace and Mechanical Engineering
University of Notre Dame
Notre Dame, Indiana
USA

Abstract

Numerical simulation of many physical phenomena, such as the formation and propagation of shock waves in compressible flow and combustion flow, present challenging computational difficulties because their solution in general possesses a wide range of space and time scales. In this work we present a fast wavelet-based adaptive multilevel collocation method combined with the method of intrinsic low dimensional manifolds (ILDM) for dealing with such problems. Some of the prerequisites for any fast algorithm are the efficient computation of derivatives and the minimization of the number of unknowns for a specified accuracy. For spatial discretization we use dilations and translations of the correlation function of the Daubechies scaling function of order 4 as basis functions. The ILDM method effectively reduces the dimension of the reaction space. Operator splitting, in conjunction with a linearized trapezoidal scheme, is used for time integration to enable the use of the ILDM method. We demonstrate the numerical algorithm by simulating the propagation and reflection of a shock wave in a shock tube, and the simulation of ignition delay of H_2/O_2 behind a reflecting shock. The results show that the numerical scheme is stable and produces accurate solutions with only a relatively small number of degrees of freedom.

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[2]Associate Professor.

[3]Professor.

[4]Graduate Assistant.

[5]Graduate Assistant.