Abstract Submitted
for the MAR16 Meeting of
The American Physical Society

Efficient Combustion Simulation via the Adaptive Wavelet Collocation Method KEVIN LUNG, ERIC BROWN-DYMKOSKI, VICTOR GUERRERO, ERIC DORAN, KEN MUSETH, JO BALME, BOB URBERGER, ANDRE KESSLER, STEPHEN JONES, BILLY MOSES, ANTHONY CROGNALE, Space Exploration Tech (SpaceX) — Rocket engine development continues to be driven by the intuition and experience of designers, progressing through extensive trial-and-error test campaigns. Extreme temperatures and pressures frustrate direct observation, while high-fidelity simulation can be impractically expensive owing to the inherent muti-scale, multi-physics nature of the problem. To address this cost, an adaptive multi-resolution PDE solver has been designed which targets the high performance, many-core architecture of GPUs. The adaptive wavelet collocation method is used to maintain a sparse-data representation of the high resolution simulation, greatly reducing the memory footprint while tightly controlling physical fidelity. The tensorial, stencil topology of wavelet-based grids lends itself to highly vectorized algorithms which are necessary to exploit the performance of GPUs. This approach permits efficient implementation of direct finite-rate kinetics, and improved resolution of steep thermodynamic gradients and the smaller mixing scales that drive combustion dynamics. Resolving these scales is crucial for accurate chemical kinetics, which are typically degraded or lost in statistical modeling approaches.

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Date submitted: 06 Nov 2015 Electronic form version 1.4