GPU-based explicit integration algorithms for accelerating chemical kinetics in CFD simulations

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New strategies for accelerating chemical kinetics in reactive-flow simulations by exploiting the performance and massive parallelism of GPUs are presented and discussed. First, the explicit fifth-order Runge–Kutta–Cash–Karp algorithm is used on the GPU to concurrently integrate large numbers of independent ODEs for nonstiff hydrogen kinetics (9 species and 38 irreversible reaction steps), showing a performance speedup of 120 compared against a single-core CPU implementation. Next, a GPU implementation of the explicit stabilized second-order Runge–Kutta–Chebyshev algorithm is demonstrated for chemical kinetics with moderate stiffness, showing improved performance by factors of 60 and 70 for a hydrogen/carbon monoxide mechanism (13 species and 54 irreversible reaction steps) and a methane kinetics (53 species and 634 irreversible reaction steps), respectively. Finally, a novel GPU-based stiff integrator is demonstrated for treating chemical kinetics with significant stiffness.