A Deferred Correction Strategy for Advection-Diffusion-Reaction Systems with Complex Chemistry

Simulation and Analysis of Reacting Flow

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Abstract

We present a deferred correction strategy for modeling low Mach number flows with advection, diffusion, and reaction processes that span a broad range of time scales. Since the time scales of diffusion and reactions are typically much faster than advection, the resulting system of PDEs is stiff. In our method, we discretize each process with a numerical method well suited for its particular time scale. Specifically, we use a second-order Godunov method for advection, a semi-implicit discretization for diffusion, and an implicit multi-step ODE solver for reactions. We couple these processes using a multi-implicit spectral deferred correction strategy, and test the performance of our algorithm on terrestrial and astrophysical flames. Our new method gives superior stability and accuracy compared to a more traditional Strang-splitting approach using comparable computational resources, and thus provides a viable alternative to Strang splitting in such settings. The overall framework also sets the stage for higher-order coupling strategies.