Parallel time integration of hyperbolic PDEs

Parallel-in-time methods, such as multigrid reduction–in–time (MGRIT) and Parareal, provide an attractive option for increasing concurrency when simulating time–dependent PDEs in modern high–performance computing environments. While these techniques have been very successful for diffusion–dominated equations, it has often been observed that their performance suffers dramatically when applied to advection–dominated problems or purely hyperbolic PDEs. In this talk, I will give a brief introduction to these algorithms and show examples of the aforementioned behaviour. I show that this degradation can be understood from existing convergence theory of these solvers, and I consider designing their components though approximately maximising convergence–rate estimates. Finally, for the canonical hyperbolic PDE of constant–coefficient linear advection, I show for the first time that fast and scalable parallel time integration is possible, achieving convergence in just a handful of iterations, even for high–order–accurate discretizations.