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Parallel-In-Time solver for the all-at-once Runge–Kutta discretization

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Time-dependent PDEs arise quite often in many scientific areas, such as mechanics, biology, economics, or chemistry. Of late, researchers have devoted their effort in devising parallel-in-time methods for the numerical solution of such PDEs, adding a new dimension of parallelism and allowing to speed-up the solution process on modern supercomputers. In this talk, we present a fully parallelizable preconditioner for the all-at-once linear system arising when employing a Runge-Kutta (RK) method in time. The resulting system is solved iteratively for the numerical solution and for the stages. The proposed preconditioner results in a block-diagonal solve for the stages, accelerated by a novel block-preconditioner based on the SVD of the RK coefficient matrix, and a Schur complement obtained by solving again systems for the stages. Parallel results show the robustness of the preconditioner with respect to the discretization parameters and to the number of stages, as well as very promising scalability and parallel efficiency indices.

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