Time stepping with rational approximations of exponential integrators: REXI 2.0

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Running simulations on large-scale high-performance supercomputers pose restrictions and therefore challenges on solving PDEs within a particular time frame. Here, disruptive mathematical reformulations which, e.g., exploit additional degrees of parallelism also in the time dimension gained increasing interest over the last two decades.

The rational approximation of exponential integration (REXI) is one of such promising methods since it allows to approximate solutions of autonomous linear PDEs of the form

$$U_t(t) = LU(t)$$

by a sum of rational terms

$$U(t + \Delta t) \approx \gamma U(t) + \sum_n \beta_n (\Delta t L - I\alpha_n)^{-1} U(t).$$

Here, a natural additional degree of parallelization is given over the terms in the sum where the coefficients γ, α_n and β_n depend on a particular method.

We will provide a brief recap of decades of work related to REXI, introduce a variety of REXI formulations (B-REXI, T-REXI, EL-REXI, CI-REXI, ...) including a discussion of various properties (workload, stability, convergence, etc.) of them. Also, we show its successful application to prototypes of single-layer atmospheric simulations.

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