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On the convergence of dual-Schur partitioned time integrators

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ABSTRACT

Partitioned time-integrators have often been used in computational science and engineering for solving coupled multidomain problems and even for single-domain problems with multiple spatial and/or temporal scales. Partitioning based on dual-Schur domain decomposition allows single-domain problems in solid and structural dynamics to be decomposed into nonoverlapping subdomains that can be solved independently using different time integration schemes and then coupled back together for greater computational efficiency. The coupling is achieved by using Lagrange multipliers to enforce continuity of the solution across the interface between the subdomains. It has been documented, through many numerical examples, that this coupling method preserves the accuracy and stability properties of the underlying time-integrators used within the individual subdomains. In this research, for the first time, we conduct a rigorous error analysis for such dual-Schur coupling methods and quantify the local and global truncation errors to show that partitioned time integrators preserve the theoretical rates of convergence within each individual subdomain and the global problem domain. We focus on a multitime-step method which allows one to couple subdomains that are solved with different time steps and time integrators from the Newmark family of schemes. We show that the second-order convergence rate enjoyed by the Newmark method for single domain problems is also preserved for partitioned systems with any time-step ratio between the two subdomains. Several numerical examples are shown to support this fact. This result lends a strong theoretical basis to the results observed only numerically heretofore in the literature and establishes an a priori error measure of error for dual-Schur partitioned numerical time integrators.