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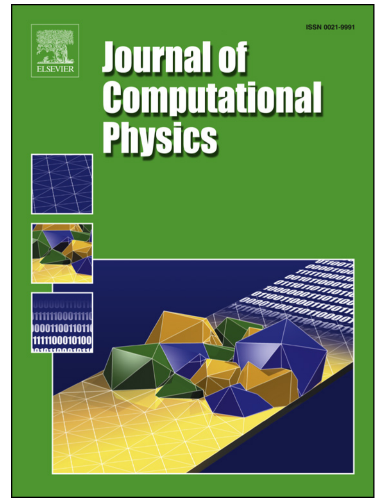

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A Stable and Accurate Partitioned Algorithm for Conjugate Heat Transfer

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Abstract

We describe a new partitioned approach for solving conjugate heat transfer (CHT) problems where the governing temperature equations in different material domains are time-stepped in a implicit manner, but where the interface coupling is explicit. The new approach, called the CHAMP scheme (Conjugate Heat transfer Advanced Multi-domain Partitioned), is based on a discretization of the interface coupling conditions using a generalized Robin (mixed) condition. The weights in the Robin condition are determined from the optimization of a condition derived from a local stability analysis of the coupling scheme. The interface treatment combines ideas from optimized-Schwarz methods for domain-decomposition problems together with the interface jump conditions and additional compatibility jump conditions derived from the governing equations. For many problems (i.e. for a wide range of material properties, grid-spacings and time-steps) the CHAMP algorithm is stable and second-order accurate using no sub-time-step iterations (i.e. a single implicit solve of the temperature equation in each domain). In extreme cases (e.g. very fine grids with very large time-steps) it may be necessary to perform one or more sub-iterations. Each sub-iteration generally increases the range of stability substantially and thus one sub-iteration is likely sufficient for the vast majority of practical problems.

The CHAMP algorithm is developed first for a model problem and analyzed using normal-mode theory. The theory provides a mechanism for choosing *optimal* parameters in the mixed interface condition. A comparison is made to the classical Dirichlet-Neumann (DN) method and, where applicable, to the optimized-Schwarz (OS) domain-decomposition method. For problems with different thermal conductivities and diffusivities, the CHAMP algorithm outperforms the DN scheme. For domain-decomposition problems with uniform conductivities and diffusivities, the CHAMP algorithm performs better than the typical OS scheme with one grid-cell overlap. The CHAMP scheme is also developed for general curvilinear grids and CHT examples are presented using composite overset grids that confirm the theory and demonstrate the effectiveness of the approach.

Keywords: conjugate heat transfer, optimized Schwarz method, domain decomposition, Dirichlet Neumann method, overset grids.

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