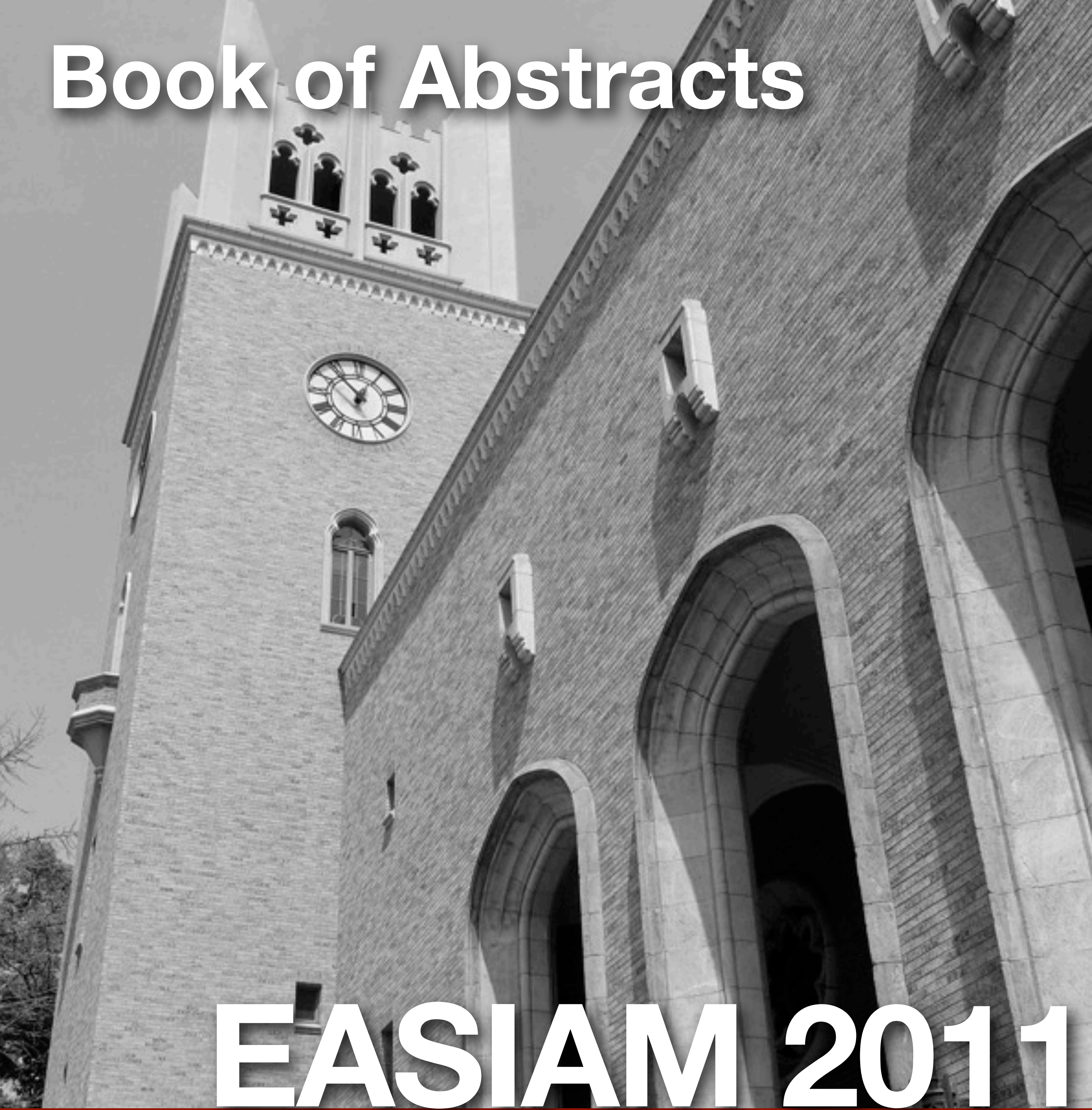

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A Coarse-Grain Parallel Scheme for Solving Poisson Equation by Chebyshev Pseudospectral Method

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Abstract

Poisson equation is frequently encountered in mathematical modeling for scientific and engineering applications. Fast Poisson numerical solvers for 2D and 3D problems are, thus, highly requested for their simulations. In this paper, we consider solving the Poisson equation $\nabla^2 u = f(x, y)$ in the Cartesian domain $\Omega = [-1, 1] \times [-1, 1]$, subject to mixed Dirichlet / Neumann boundary conditions, discretized with the Chebyshev pseudospectral method. The main purpose of this paper is to propose a reflexive decomposition scheme for orthogonally decoupling the linear system obtained from the discretization into independent subsystems via the exploration of a special reflexivity property inherent in the second-order Chebyshev differentiation matrix. The decomposition not only yields more efficient algorithm but introduces coarse-grain parallelism. This approach can be applied to more general problems and to other partial differential equations discretized with the Chebyshev pseudospectral method as well, so long as the discretized problems possess reflexive symmetry. Numerical examples and the performance of numerical experiments are presented to demonstrate the validity and advantage of the proposed approach.

Keywords Poisson equation, Chebyshev pseudospectral method, Chebyshev differentiation matrix, Coarse-grain parallelism, Reflexivity property

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