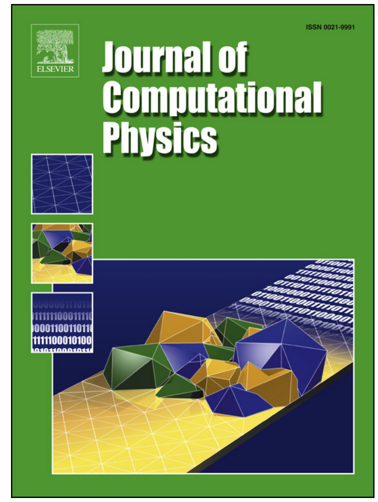

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A new definition of fractional Laplacian for modeling three-dimensional nonlocal heat conduction

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Abstract

This paper proposes a new implicit definition of the fractional Laplacian. Compared with the existing explicit definitions in literature, this novel definition has clear physical significance and is mathematically simple and numerically easy to calculate for multidimensional problems. In stark contrast to a quick increasing and extensive applications of time-fractional derivative to diverse scientific and engineering problems, little has been reported on space-fractional derivative modeling. This is largely because the existing definitions are only feasible for one-dimensional case and become mathematically too complicated and computationally very expensive when applied to higher dimensional cases. In this study, we apply the newly-defined fractional Laplacian for modeling the power law behaviors of three-dimensional nonlocal heat conduction. The singular boundary method (SBM), a recent boundary-only collocation discretization method, is employed to numerically solve the proposed fractional Laplacian heat equation. And the computational costs are observed moderate owing to the proposed new definition of fractional Laplacian and the boundary-only discretization, meshfree, and integration-free natures of the SBM technique. Numerical experiments show the validity of the proposed definition of fractional Laplacian.

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