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Summary: In this paper, a finite difference scheme is proposed to solve high-dimensional Klein-Gordon equation. It is proved that the proposed scheme preserves the total energy in the discrete sense. Without any grid-ratio restriction, the optimal $H^1$-error estimate is established, and the convergence rate is of $O(h^2 + \tau^2)$ with time step $\tau$ and grid size $h$, while the previous work in the literature always requires certain restriction on the grid ratio. Numerical results are carried out to verify the theoretical results.

MSC:
65M06 Finite difference methods for initial value and initial-boundary value problems involving PDEs
65M12 Stability and convergence of numerical methods for initial value and initial-boundary value problems involving PDEs
65M15 Error bounds for initial value and initial-boundary value problems involving PDEs

Keywords:
Klein-Gordon equation; finite difference method; energy conservation; optimal error estimate; unconditional convergence