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Discretize and Conquer: How to Access Fundamental Physics from Numerical Computations

A number of numerical approaches has been developed to study quantum field theories in non-perturbative regimes. One method consists in confining space-time to a finite volume and discretizing it, allowing for ab initio simulations. In the case of Quantum Chromodynamics (QCD), this framework is known as Lattice QCD. Another strategy is to numerically diagonalize the Hamiltonian of the theory, which becomes feasible by truncating its energy spectrum. Within the lattice approach, we demonstrate how to extract from correlators computed in Lattice QCD the light-front wave functions of baryons — such as the proton — which encode information on the configurations of the elementary constituents. For the Hamiltonian-truncation approach, we present our results for the $\lambda\phi^4$ theory in $1+1$ dimensions, where an effective theory can be constructed to mitigate the computational resources needed to achieve convergence.

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