A unified RG approach to quantum simulation of bosonic and fermionic field theories

Alexander Stottmeister

Institut für Theoretische Physik, Leibniz Universität Hannover

Quantum field theory (QFT) describes quantum systems with infinitely many degrees of freedom, modeling the most subtle and complex phenomena in statistical and high energy physics. Improving the understanding of QFT remains a major challenge due to its enormous scope. Initial successes of QFT in the weakly interacting regime are based on perturbation theory, still relevant today. Non-perturbative methods are required for insights into the structure of strongly interacting QFT, enabling, for example, the ab-initio computation of hadron masses.

The renormalization group (RG) in combination with lattice approximations is such a method, effectively truncating systems to finitely many degrees of freedom relevant at the observational scale. The most general RG is formulated in (quantum) statistical mechanics and connects to QFT through scaling limits of critical systems. This general RG is a well-developed and important tool in imaginary- time QFT. It is far less developed in real-time QFT, which is entering a new era of exploration due to tremendous progress in quantum computing.

A new RG formulation, coined operator-algebraic renormalization (OAR) can close this gap providing access to real-time QFTs via quantum scaling limits (QSLs). Here, I will discuss a unified approach to quantum simulation of bosonic and fermionic QFTs in this framework.