The exact solution to interacting quantum problems is in general an exponentially hard task due to the exponential growth of the Hilbert space with the system size. As a result, despite extensive research during the past several decades we still do not have a good understanding of strongly correlated systems even for the simplest ones such as the Hubbard model. We can only obtain exact results for special and very limited classes of models. For example, quantum Monte Carlo (QMC) method which evaluates path integrals stochastically is an exact and unbiased numerical method provided the notorious sign-problem is absent.

In this talk, I will introduce our recently developed algorithm that can find the reduced density matrix associated with a finite subsystem of an infinite system. This paradigm was inspired by ideas from Hawking-Unruh radiation in black hole physics. As an example, I will demonstrate that this method can obtain the exact ground-state energy and scaling dimensions of the 1D Heisenberg model in the thermodynamic limit by solving a few sites problem. I will then show that within this new approach, the sign problem is practically circumvented and QMC can be applied to generic local models even at extremely low temperatures. I will finally show that this paradigm can also enhance the accuracy of matrix/tensor product states significantly by allowing gigantic bond dimensions.