Hybrid Classical/Quantum Monte Carlo Algorithm
Applied to XXZ model

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Abstract—A novel decomposition of the canonical partition function is presented that allows for a quantum Monte Carlo algorithm with updates that are distinctly classical or quantum mechanical. This allows the algorithm to behave more classically in regimes where quantum effects are negligible and therefore reduce computation time. The method is applied to the XXZ model to study the importance of quantum mechanically effects at various temperatures and external magnetic field. Add major conclusions.

Keywords-Monte Carlo; spin systems; XXZ-model

I. INTRODUCTION
Quantum Monte Carlo (QMC) simulations have been extensively used in recent years to study the many-body problem in quantum mechanics. These simulations are very effective at describing large systems for which exact diagonalization is not feasible. Sandvik (2003)[?] developed the stochastic series expansion method capable of solving quantum Ising models of system size $N$ with computation time scaling as $N \ln(N)$. However, in nature, quantum effects are often only important close to specific areas in ’phase space’ for example, ferro-magnetic spin systems behave classically in the presence of even a weak external magnetic field. Therefore computation time could be strongly decreased by using a hybrid Monte Carlo algorithm that behaves quantum mechanically only in those regimes of the system where quantum effects are important and classically everywhere else. Here we present such an algorithm relying on a novel decomposition of the partition function distinctly different from the standard path integral method, without the need for truncating the Taylor expansion.

In part II we present the decomposition of the partition function and an application to the XXZ model.

II. METHOD
A. Decomposition of the Partition Function
Subsection text here.

B. Algorithm for XXZ model
Talk about update steps, numerics needed to accurately calculate weights and parallization of algorithm.

III. RESULTS
The most important result would be a plot showing speed-up of the new algorithm versus standard SSE algorithms. We will also show the extent to which quantum effects are important at different temperatures (we call this ’quantumness’ of the system). Preliminary results is shown in Fig. 1.

![Figure 1. Plot showing number of off-diagonal operators included in simulation at different temperatures.](image)

IV. CONCLUSION
The conclusion goes here.

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REFERENCES