Phys730 Mid-Term-Project Proposal

Khagendra Adhikari

February 26, 2016

Numerical Solution of Quantum Heisenberg Chain

1 Introduction

The $S = \frac{1}{2}$ isotropic quantum Heisenberg chain is a model of mutually interacting quantum spins arranged with regular spacing along a line. The interaction is limited to nearest-neighbour spins and the nature of interaction is antiferromagnetic $(J > 0)$, meaning that they favor the opposite alignment of spins.

$$\hat{H} = J \sum_{i}^{L} \left[\frac{1}{2} \left(\hat{S}_i^+ \hat{S}_{i+1}^- + \hat{S}_i^- \hat{S}_{i+1}^+ \right) + \hat{S}_i^z \hat{S}_{i+1}^z \right]$$

Where L is the length of the chain.
In 1931, the model was solved analytically by Bethe and the exact ground state energy per site is $E_0 = \frac{1}{4} - \log_e(2)$.

2 Computational Method

Python code will be written to generate a Hamiltonian matrix and to calculate its eigenvalues.The lowest eigenvalue is the ground state energy. The Calculation will be carried out on finite-size system of increasing size, and the result will be extrapolated to the thermodynamic limit. Numerical result will be compared to the known result.

3 Tool

numpy
scipy
matplotlib