Quantum Information and Computing

Assignment 7 (due in two weeks)

December 3, 2024

1. **Ising model** Consider N spin-1/2 particles on a one-dimensional lattice, described by the Hamiltonian:

$$\hat{H} = \lambda \sum_{i}^{N} \sigma_i^z + \sum_{i}^{N-1} \sigma_i^x \sigma_{i+1}^x \tag{1}$$

where σ_x and σ_z are the Pauli matrices and λ is the interaction strength.

   (a) Write a program to compute the N x N matrix representation of the Hamiltonian $\hat{H}$ for different N.

   (b) Diagonalize H for different $N = 1, ..., N_{max}$ and $\lambda \in [0, -3]$. What is the largest is N_{max} you can reach?

   (c) Plot the first k levels as a function of λ for different N and comment on the spectrum.