

# Computational Quantum Physics

## Week 9

### Due on Week 10

#### Exercise 1: Ising Model

Consider  $N$  spin-1/2 particles on a one-dimensional lattice, described by the Hamiltonian

$$\hat{H} = \lambda \sum_i^N \sigma_z^i + \sum_i^{N-1} \sigma_x^{i+1} \sigma_x^i,$$

where  $\sigma$ 's are the Pauli matrices and  $\lambda$  is the interaction strength.

- (a) Write a program that computes the  $2^N \times 2^N$  matrix representation of the Hamiltonian  $\hat{H}$  for different  $N$ .
- (b) Diagonalize  $H$  for different  $N = 1, \dots, N_{max}$  and  $\lambda \in [0 : 3]$ . How big is  $N_{max}$  you can reach?
- (c) Plot the first  $k$  levels as a function of  $\lambda$  for different  $N$ . Comment the spectrum.