Quantum Information and Computing

Assignment 3 (due in two weeks)

October 29, 2024

1. **Scaling of the matrix-matrix multiplication.** Consider the code developed in the Exercise 3 from Assignment 1 (matrix-matrix multiplication):

   (a) Write a python script that changes N between two values N_{min} and N_{max}, and launches the program.

   (b) Store the results of the execution time in different files depending on the multiplication method used.

   (c) Fit the scaling of the execution time for different methods as a function of the input size. Consider the largest possible difference between N_{min} and N_{max}.

   (d) Plot results for different multiplication methods.

2. **Eigenproblem.** Consider a random Hermitian matrix A of size N.

   (a) Diagonalize A and store the N eigenvalues λ_i in ascending order.

   (b) Compute the normalized spacing between eigenvalues $s_i = \frac{\Lambda_i}{\bar{\Lambda}}$ with $\Lambda_i = \lambda_{i+1} - \lambda_i$ and $\bar{\Lambda}$ is the average Λ_i

3. **Random matrix theory.** Study $P(s)$, the distribution of normalized spacing s defined in the previous exercise, accumulating values from different random matrices of size at least N = 1000.

   (a) Compute $P(s)$ for a random hermitian matrix.

   (b) Compute $P(s)$ for a diagonal matrix with real random entries.

   (c) Fit the corresponding distributions with the function: $P(s) = as^{\alpha} exp(bs^{\beta})$ and report a, b, α, β. *Hint: if necessary, neglect the first eigenvalue*