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