

# Quantum Information and Computing

## Assignment 3 (due in two weeks)

November 7, 2023

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  $\lambda_i$  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  $\Lambda_i$
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  $a, b, \alpha, \beta$ .  
*Hint: if necessary, neglect the first eigenvalue*