Computational Quantum Physics

Week 8

Due on Week 9

Exercise 1: **Density Matrices**

Given a quantum system formed by N subsystems (spins, atoms, particles etc..) each described by its wave function $\psi_i \in \mathcal{H} = \mathbb{C}^d$, a d-dimensional Hilbert space.

How do you write the total wave function of the system $\Psi(\psi_1, \dots \psi_N)$? Write a Fortran code to

(a) describe a N-body non interacting, separable pure state

(b) a general N-body pure wave function $\Psi \in \mathcal{H}^{\otimes N}$.

Comment on their efficiency. How large N can be? Furthermore, setting N=2:

(a) Write the density matrix of a generic pure state Ψ, $\rho = |\Psi\rangle\langle\Psi|$.

(b) Given the generic density matrix ρ compute the reduce density matrix of either the left or the right system, e.g. $\rho_1 = \mathrm{Tr}_2\, \rho$.

(c) Test the functions described before (and all others needed) on two-spin one-half (qubits) with different states.