

Problem set 4: Pure versus mixed states, density matrices *Due 12 Oct 2007*

1) What is the density matrix for each of the Bell pairs? Now imagine I have a bag full of Bell pairs, with equal numbers of pairs in the state $(|00\rangle + |11\rangle)/\sqrt{2}$, $(|00\rangle - |11\rangle)/\sqrt{2}$, $(|01\rangle + |10\rangle)/\sqrt{2}$ and $(|01\rangle - |10\rangle)/\sqrt{2}$, and I pull out one pair from the bag. What is the density matrix describing this two-particle state? Are the two particles entangled?

2) Compute the reduced density matrices, ρ_A and ρ_B , for the following joint states of two particles, A and B , and determine whether the particles are entangled.

$$\frac{1}{2} \begin{pmatrix} 1 & 0 & -i & 0 \\ 0 & 0 & 0 & 0 \\ i & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \quad \frac{1}{4} \begin{pmatrix} 1 & 0 & -i & 0 \\ 0 & 1 & 0 & i \\ i & 0 & 1 & 0 \\ 0 & -i & 0 & 1 \end{pmatrix}$$