Quantum Computing: An Applied Approach

Chapter 2 Problems: A Brief History of Quantum Computing

1. Do the following physical systems satisfy DiVincenzo's criteria? For each system state which of the criteria the system violates, if any.

   (a) A set of five trapped ion qubits that can be initialized to the $|0\rangle$ state and measured in the Z basis with the ability to implement arbitrary single qubit rotations.

   (b) A system with 5,000 qubits that can find the ground state, but the individual qubits are not addressable.

2. If we are operating on 3-vectors, how are we able to use 2x2 matrices? If your first answer is that we are using complex numbers as entries in the matrix then that would lead to operating effectively on 4-vectors as $\mathbb{C}^2$ is equivalent to $\mathbb{R}^2$.

   Are there dimensional shenanigans going on here? A priori, a state vector is a two-complex-dimensional vector and a two-complex-dimensional vector is in fact a four-real-dimensional vector. So, how is it that a state vector could be reasonably represented as a point on a sphere, which lives in three-real-dimensional space? Secondly, if we believe that these state vectors are fairly described as elements of a sphere in three-real-dimensional space, why then is it fair to act on them with two-complex-dimensional matrices?

3. For the CZ gate, does it matter which qubit is the control qubit and which is the target?