

# Some essential questions to be able to answer in preparation for the Physics 130C final exam

Lecturer: McGreevy

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1. Axiom 3: Given a state  $|\psi(0)\rangle$  at time  $t = 0$ , and a Hamiltonian  $\mathbf{H}$ , what is the state at time  $t$ ?
2. Axiom 4: Given a state  $|\psi\rangle$  and a Hermitian operator  $\mathbf{A}$  with eigenvalue  $a$ , what is the probability that will get  $a$  if we measure  $\mathbf{A}$  in the state  $|\psi\rangle$ ?
3. Axiom 4 for mixed states: Given a density matrix  $\rho$  and a Hermitian operator  $\mathbf{A}$  with eigenvalue  $a$ , what is the probability that will get  $a$  if we measure  $\mathbf{A}$  in the state  $\rho$ ?
4. Reduced density matrix: Given a state  $\rho$  of a composite system  $\mathcal{H}_A \otimes \mathcal{H}_B$ , construct the reduced density matrix

$$\rho_A \equiv \text{tr}_{\mathcal{H}_B} \rho .$$

What information does this encode? Under what circumstances does the resulting  $\rho_A$  describe a pure state?

5. The density matrix encodes a probability distribution on state vectors: In its spectral representation

$$\rho = \sum_a p_a |a\rangle\langle a|$$

(the states  $|a\rangle$  are orthonormal since  $\rho$  is Hermitian),  $p_a$  is the probability that the system is in the state  $|a\rangle$ .

6. More generally, what are the connections between the notions of entanglement, interactions, pure states, mixed states?
7. Ehrenfest's Theorem: Given an observable  $\mathbf{A}$  and the Hamiltonian  $\mathbf{H}$ , what is

$$\partial_t \langle \mathbf{A} \rangle ?$$

8. Path integral: From the point of view of quantum mechanics, what is special about the classical trajectory?