

Examples of possible exam questions for “Foundations of Quantum Mechanics”

What does unitarity mean? Give an example of a unitary operator. Can you verify its unitarity? Do we also sometimes consider a non-unitary time evolution? Give an example and explain why in this example time evolution is not unitary.

What does time reversal invariance mean? Give an example of a theory that is time reversal invariant and one that is not. Can you do a calculation to verify the invariance?

What is the relation between spin space C^2 and physical space R^3 ? Which properties do the Pauli matrices have? How does a Stern-Gerlach experiment proceed? What are the possible outcomes and their probabilities? Describe the spin space for N particles of spin $1/2$. Give an example of an entangled spin state. Which Hamiltonians turn disentangled states into entangled ones?

What does the projection postulate of quantum mechanics assert? Derive it from Bohmian mechanics. Describe the measurement problem. What are the possible ways out?

What are the defining equations of Bohmian mechanics? What is equivariance? Why can't the trajectories cross? In 1d, what is special about the quantiles of the Born distribution? Can you prove that? In a double-slit experiment, how can you figure out through which slit the Bohmian particle passed without disturbing the interference pattern?

Describe the EPR argument. What does it show? What does Bell's theorem say? What is the quantum prediction for Bell's experiment? Einstein's boxes argument proves some theories non-local and others not; give an example of each.

What is a statistical density matrix? Which operators can occur as one? Why? What does the main theorem about POVMs imply about probability distributions with the same statistical density matrix? What does the von Neumann equation say? What does it describe? Write down the trace formula. What is a reduced density matrix? What is a partial trace?