24.111: Philosophy of Quantum Mechanics, Spring 2016
Homework 5

1. Suppose you've seen a proof of Bell's theorem but haven't yet done any experiments. (So you don't know, yet, whether quantum mechanics is true, or a local hidden variables theory is true.) If you choose just one experiment (say, $(0°, 120°)$), and perform that experiment just once on a pair of particles in the singlet state, the outcome of that one experiment cannot tell you whether a local hidden variables theory is true. (That is, the local theory and quantum mechanics do not disagree about the outcome of any single experiment considered in isolation.) Explain why.

2. Suppose (hypothetically!) that we have created a device that, as in the EPR experiment, emits two particles in opposite directions. Suppose that there are three properties we can measure on each particle: A, B, and C. And suppose that a measurement of any of these properties can have one of two outcomes: "yes" or "no" (or, if you like: $+1$ or -1). So we could choose to measure A on particle 1 and B on particle 2; or measure C on both particles; and so on.

We do a variety of measurements on pairs of particles and collect statistics. We discover the following two facts:

> Fact 1: when we measure the same property on both particles, the outcomes always agree.
>
> Fact 2: when we measure different properties on both particles, the outcomes always disagree.

A local theory of the behavior of the particles will say that a measurement of a property on particle 1 in this experimental set-up does not influence the outcome of the measurement on particle 2. Prove that, given these facts, no local theory of the behavior of the particles could be true. (Note: you should not say anything about quantum mechanics, the theory, in your answer. Facts 1 and 2 are not derived from that theory, nor can they be derived from it when considering any of the experiments we have discussed.)

3. Read the excerpt from the Mermin paper "A Bolt from the Blue" (available on the readings page). In that paper Mermin makes a false statement about the relationship between the EPR argument and Bell's theorem. What is the false statement? Why is it wrong? Explain your answer fully.