Project ideas: EPR, Bohr, Bell, Nonlocality

A "project" is meant to be something half way between a homework assignment and a paper. For technically oriented projects, the length might be no more than a couple pages. For historically oriented projects, the length might be closer to six pages (double spaced). Our goal is for you to use this project as an excuse to investigate something that you are curious about. Please feel free to use one of the ideas below as your jumping off point, or to make up your own project.

1. In the Bell notes, it's claimed that the Bell inequality can only be violated if both Alice and Bob have a pair of **non-commuting** operators. Prove this fact.

2. Graph the expectation values in the singlet state of the Bell observable

   $$R = A_1(B_1 + B_2) + A_2(B_1 - B_2),$$

   as a function of θ, where $B_1 = I \otimes S_\theta$. Find the range in which Bell's inequality is violated, and find the value where Bell's inequality is maximally violated.

3. Write out the EPR argument for the simultaneous reality of B_1 and B_2 (Bob's position and momentum, or $I \otimes S_z$ and $I \otimes S_x$). In doing so, provide a clear formulation of the EPR reality criterion. Take a stance on whether or not the argument is valid.

4. What is locality and why is it important? Is there a sense of locality that is not undermined by the violation of Bell's inequality?

5. Evaluate the debate between Maudlin and Werner over whether the violation of Bell's inequality implies nonlocality. Or simply argue for one side of the issue.

6. In his answer to EPR, Bohr repeatedly accuses them of being "ambiguous." Based on what he says in this paper, what do you think he's getting at?