Quantum Theory (PHYS 450): Week 6

Spring 2008 v1.0

EPR Week!! We will focus on the EPR experiment and its descendants including Bell inequalities. These terms cover some truly baffling aspects of the quantum world. I have reduced the number of problems so you can dig into this stuff.

We'll also return to a part of quantum mechanics that you have seen before - 1D wave mechanics! In the first part of Chapter 6 Townsend makes the transition to position and momentum states. He does this in a way that recalls both the work on rotations in Chapter 1 and on evolution in Chapter 4

NOTE BENE: We have a mid-term next week.

Enjoy!

Reading:

Townsend Chapter 5, sections 5.4-5.6

The EPR paper. The reference is given in footnote 7. You should be able to access it from any computer on campus just seach for Physical Review and type in the volume and page numbers. http://academics.hamilton.edu/physics/smajor/Papers/tale.html You can get to this from the course page by clicking on 'Seth's Net Home' then 'Physics Links' then 'tale' under non-technical writing.

Townsend Chapter 6

Problems:

Problems are due at the beginning of seminar. Please make a copy of your solutions before you arrive.

(1) Fun with raising and lower operators care of Kosta:
   (a) Using the definition of raising/lowering operators and
   $$\hat{S}_x = \frac{\hbar}{2}\sigma_x, \quad \hat{S}_y = \frac{\hbar}{2}\sigma_y$$
   find the matrix representation for $\hat{S}_+$ and $\hat{S}_-$ in the z-basis.
   (b) Using the states $|\pm z\rangle$ check that these raising and lower operators "do the right thing".
   (c) Suppose now you have two spin-1/2 particles. Using the $|1\rangle - |4\rangle$ basis find the matrix for the operator
   $$\hat{S}_{1_+}\hat{S}_{2_-}$$

(2) 5.4
(3) 5.5
(4) 6.1 (b), (c)
(5) 6.2
(6) 6.10

Seminar Presentations:

Come to seminar with your presentation notes complete. If you have any doubt about your presentations, please ask questions before seminar.

- Jordan: Work through the details of Section 5.5. Present the core idea(s) without lots of algebra (If you find you have to work through lots of algebra, then write it up and hand out copies of your work.) What does this argument mean?
- Wex: Compare the original EPR 'experiment' with the more modern version presented in the text.
- Ruth: Read Chapter 6 in Styer's The Strange World of Quantum Mechanics. Carefully describe and present the results of local determinism. Feel free to dig into this by exploring the other references. Select one of Styer's Chapter 6 problems to present.

- Walter: Read Chapter 5 in Greenstein and Zajonc, *The Quantum Challenge* and tell us about hidden variables including their example theory.
- Dan C.: Read "On the EPR paradox" by John Bell. You can find it in the collection of his work *Speakable and Unspeakable in Quantum Mechanics.* Give us the highlights of the proof of Bell's inequalities. That is, find the difficult bits and guide us through them. See also, if you wish, Section 5.4 in Greenstein and Zajonc, *The Quantum Challenge.*
- Nguyen: Present experimental results on the Bell inequalities. Read over the Aspect papers cited in the footnotes 11 and 12. There is also a good discussion of this, at an introductory level, in Greenstein and Zajonc, *The Quantum Challenge*, Chapter 6.
- Mike: Read Chapter 7 in Styer's The Strange World of Quantum Mechanics. Carefully describe and present the GHZ experiment. Feel free to dig into this by exploring the other references, see Greenstein and Zajonc, *The Quantum Challenge* section 6.6
- Emily: What is a solution to the trial?
- Dan T.: What is this translation operator anyway? Explain how it is related to momentum.
- Seth: If there is time I'll discuss a simple proof of Bell's inequalities, Tsierson's inequality and quantum hidden variables.