Quantum Theory (PHYS 450): Week 5

Spring 2008 v1.0

We'll address two aspects of time evolution this week, the two-level system of the ammonia molecule and the energy-time uncertainty relation. However the main topic will be the *addition of angular momentum* - what it is and how it affects physics of particles and atoms. Next week our discussion will be based on particular angular momentum states.

I've changed the mix of presentations this week, partly because I don' t think we have been able to address questions about your solutions. We'll also try "solution experts", folks who are prepared to answer questions on solutions. Let me know what you think of the format - and feel free to suggest changes!

As I mentioned at the beginning of the semester I would like to assign a take-home midterm shortly. It will be an open book, limited time exam. I am planning to make it available mid-week. You will have a week to take the exam.

Reading:

Townsend Chapter 5, sections 5.1-5.3 (alternative and breezy treatment Davies and Betts, sections 7.8, 9.1, 9.2)
Townsend Appendix B

Notes on text:

- pages 120-130: You may want to read this several times, the first just to get the big picture, the rest for detail. The basic idea: we're combining states of more than one spin-1/2 particle.
- page 126: How should you interpret equation 5.21?
- page 128-9: Singlet and triplet states are key concepts

Problems:

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

(1) 3.15 All the eigenstates of $\hat{S}_x$ in the z-basis.
(2) 4.5 You may find that your solution to 3.2 is helpful.
(3) 4.6
(4) 4.13 A 3-state system similar to Emily's presentation last week.
(5) 4.14
(6) 4.15
(7) 5.1 If you have trouble finding the determinant let me know what method you are using and I'll send along hints and/or the result.
(8) 5.2 Just write the states out and expand.
(9) 5.3

Seminar Presentations:

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

- Dan T: Review the key results of the ammonia molecule (pgs 108-113). Present problem 4.10 - Rabi's formla for ammonia. If you find that there is a bunch of algebra, please prepare a handout for the seminar.
- Nguyen: Introduce the energy-time uncertainty relation. Explain the nature of Δt. Present a solution to Griffiths *Introduction to Elementary Particles* 1.2 (be sure to present the commentary). Be prepared to answer questions on the solution to 4.15.

- Walter: Supplement Townsend's presentation by defining a "direct product". See Cohen-Tannoudji Chapter II F and Complement DIII. Give an example for 2D vector spaces.
- Michael: Present hyperfine splitting in hydrogen (122-126). In your presentation clearly explain what interaction gives rise to the effect, any sticky points in the derivation, and the dynamics of the hydrogen 21 cm line. What role does this line play in the study of astronomy of interstellar gas clouds or of other fields?
- Dan C: Present the examples of addition of angular momentum from Griffiths *Introduction to Elementary Particles* Section 4.3. Include the definition of Clebsch-Gordon coefficients and their physical interpretation.
- Emily-Ruth-Wex: Be prepared to answer questions on 3.15, 4.5, 5.1, and 4.13
- Seth: (if time) If there is time I'll show you a diagrammatic method for adding angular momentum states - spin networks. We'll see how these are related to quantum geometry. See *Am. J. Phys.* **67** (1999) 972-980 for details.