Physics 223B, spring 2014

Problem set 1

Due: Start of class Tuesday, January 14

1) On line 7 of p. 20, there is an error. Find and correct it.
2) Just above Definition 2.8, there is the assertion *"One can also show that either H and H' coincide completely or they have only the identity element in common."* Either show it or produce a counter example. I just noticed that a newer printing has changed this statement. So if you have the new version of the statement, you can do the same for it, i.e. either prove it or produce a counterexample.
3) Tung problem 2.8

Problem set 2

Due Tuesday, Jan. 21

In Tung, 3.1, 3.2, 3.5, 3.6, 3.12.
For part i of 3.12, make a list of the irreps with their dimensions. Do not write out the representation matrices explicitly.

Problem set 3

Due Tuesday, Jan. 28.

1) Consider scattering in a basis that diagonalizes angular momentum: $|nJM>$. The S-matrix is rotationally invariant. Conservation of angular momentum gives $< n'J'M'|S|nJM >= \delta_{JJ'}\delta_{MM'} < n'JM|S|nJM >$. What additional information about $< n'JM|S|nJM >$ can be obtained from the Wigner-Eckart theorem?
2) In class, I discussed the case of the angular momentum **J** as an irreducible tensor operator and computed a couple of sample matrix elements. Carry this on in the same approach and compute and discuss the following cases (Don't forget to use the relation between J and O that I gave in class.)

   i) $< 1/2, -1/2|J_-|1/2, 1/2 >$
   ii) $< 1/2, 1/2|J_+|1/2, 1/2 >$
   iii) $< 3/2, 3/2|J_+|1/2, 1/2 >$

3) Refer to the solution to quiz 4. Suppose that the answer for the z matrix element had been A, then what would the result for the x matrix element be? (This will require analogy with the discussion of the **J** components.)

Problem set 4

Due Tuesday, Feb. 11

Note that this assignment is four problems: two from Tung, one from Georgi, and one from me.

Tung 7.4 and 7.9
In Tung 7.9 (iii), there is a typo. It should read $(T_{ij} + T_{ji})/2$. Also, for the second part of part (iii) of this problem, use general arguments such as your knowledge of the decomposition of direct products (p. 123). Do not do an explicit and tedious calculation.

Georgi, problem 4.B

Consider the elastic scattering of a spin-1 photon (helicity states $\lambda = \pm 1$ but not $\lambda = 0$!) on a spin-1/2 proton in the center of momentum system. Suppose that the scattering is entirely in the $J = 3/2$ channel. Take $\hat{z}$ as the direction of the initial state photon. For the process with all initial and final state helicities positive, what is the angular distribution of the final state photon (i.e. the angular dependence of the differential cross section $\frac{d\sigma}{d\Omega}(\theta, \varphi)$)? Look up rather than compute any d's that you need. What happens at $\theta = \pi$ and why?

Problem set 5

Due Tuesday, Feb. 18

Tung 10.5 and 10.6

Comments:

- These problems are similar to problem 7.9.
- Consider the dual tensor

$$\tilde{F}^{\mu\nu} \equiv \frac{1}{2}\epsilon^{\mu\nu}{}_{\alpha\beta}F^{\alpha\beta} \tag{1}$$

and

$$F^{\mu\nu}_{\pm} \equiv \frac{1}{2}(F^{\mu\nu} \mp i\tilde{F}^{\mu\nu}). \tag{2}$$

- Think in terms of previous work: irreps and the decomposition of direct products. In what way does $t^{\mu\nu}$ carry a direct product rep?
- Avoid explicit calculations; use counting and general results.
- "transform as" means carries the indicated irrep.

Problem set 6

Due Tuesday, Mar. 4

Georgi 6.B, 7.C, 9.A

Problem set 7

Due Thursday, Mar. 13

Georgi 10.A, 12.C, 16.B
