HW #9
Intermediate Quantum 491

Townsend problems from Chapter 5:

5.1) Hyperfine splitting of Hydrogen in a constant magnetic field. Define the dimensionless parameter $\alpha = \frac{\omega_0 \hbar}{2A}$. Make a sketch of the energy level diagram of the eigenstates as a function of α in the limits $\alpha << 1$ and $\alpha >> 1$

5.2) Also show that the product z-states $|1, m\rangle_z$ in the z-basis transform under a rotation of $\pi/2$ about the y-axis according to the rotation matrix for a spin-1 particle given in problem 3.19. Show that the state $|0, 0\rangle_z$ transforms as a scalar.

5.3) Before doing the calculation, you should be able to guess the answer. Do the calculation. Do you get what you expected?

4) In an EPR experiment the orientation of the device A makes an angle θ with respect to that of device B. Show that 50% of B's measurements give $+\hbar/2$ and 50% give $-\hbar/2$. Note that the possible outcome states form a basis.

5.5) Is angular momentum conserved? Why or why not.

5.9) Use the spinor rotation matrix.

5.13) This experiment was done to measure the spin and parity of the positronium ground state which must be the same as the spin-parity of the photon state. What is the spin and parity of the photon state? Parity of the state is the sign of the wave function under particle exchange. You can look at the parity of the plane polarization state, or note that the parity of a linear momentum is negative (a vector is odd under coordinate inversion) and an angular momentum ($\vec{r} \times \vec{p}$) is positive. So under parity, what happens to the states $|RR\rangle$, $|LL\rangle$?