

**Lecture summary**

- Fluorescence, angular distribution and polarization (revisit)
- Atomic parity non-conservation
- Wigner-Eckart Theorem
- Optical pumping
- Wigner's 6-j symbol
- Magnetic dipole moment
  - Bohr magneton, nuclear magneton
  - g-factor
- Nuclear moments
  - Magnetic, electric
  - Monopole, dipole, quadrupole
  - Parity and time-reversal symmetry
- Magnetic dipole hyperfine interaction,  $A_I$  coefficient
- Hyperfine structure of the hydrogen 1S level
- M1 transition
  - Lifetime
  - Selection rules
- Electric quadrupole hyperfine interaction,  $B_I$  coefficient

**Homework**

1. In the hydrogen atom, the  $2^2P_{3/2}$  ( $F = 1, M_F = +1$ ) state can decay to three possible states in the ground-level  $1^2S_{1/2}$ :  $F = 1, M_F = +1$ ;  $F = 1, M_F = 0$ ;  $F = 0, M_F = 0$ .
  - a. Compute the branching ratios of all three decay channels using the 3-j, but not 6-j symbols.
  - b. Compute the branching ratios of all three decay channels using both the 3-j and 6-j symbols.
$$\begin{aligned} &\langle n' F' M_{F'} J' I | r_q | n F M_F J I \rangle \\ &= (-1)^{J' + I - M_{F'}} \cdot \sqrt{(2F + 1)(2F' + 1)} \cdot \begin{Bmatrix} J' & F' & I \\ F & J & 1 \end{Bmatrix} \\ &\quad \cdot \begin{pmatrix} F & 1 & F' \\ M_F & q & -M_{F'} \end{pmatrix} \cdot \langle n' J' || r || n J \rangle \end{aligned}$$
  - c. Calculate the spatial distribution of the fluorescence emissions from this excited state.
2. Plot the B field near a magnetic quadrupole moment (MQM). What is the least value of the spin of a particle for it to possess a MQM? Show that if a particle possesses a permanent MQM, the effect violates both parity and time-reversal symmetry.
3. Textbook Exercise (6.4) Ratio of hyperfine splittings
4. Textbook Exercise (6.5) Interval for hyperfine structure

5. Textbook Exercise (6.7) Hyperfine structure

**Reading Assignments:**

Putting a spin on light and atoms: how to build a better magnetometer  
<https://phys.org/news/2010-09-atoms-magnetometer.html>

Time Reversal, by A. Zee, Discovery magazine, Oct. 1, 1992.  
<http://discovermagazine.com/1992/oct/timereversal140>