

PHY 741 – Problem Set #23

Finish reading Chapter 7 and begin Chapter 10 in **Mahan**; homework is due Friday, November 5, 2010.

Consider a proton in an initial pure spin state

$$\Psi(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix}.$$

At $t = 0$, the proton enters a magnetic field of the form

$$\mathbf{B} = B_1(\cos(\Omega t)\hat{\mathbf{x}} + \sin(\Omega t)\hat{\mathbf{y}}) + B_0\hat{\mathbf{z}}, \quad (1)$$

where the rotation field strength is small ($B_1 \ll B_0$) compared to the constant field in the $\hat{\mathbf{z}}$ direction. The frequency Ω meets the resonance condition

$$\Omega = \Omega_0 = -2\mu_p B_0/\hbar.$$

1. Write a general expression for the proton spin wavefunction $\Psi(t)$.
2. Evaluate the time dependent expectation values
 - (a) $\langle \Psi(t) | s_z | \Psi(t) \rangle$.
 - (b) $\langle \Psi(t) | s_x | \Psi(t) \rangle$.
 - (c) $\langle \Psi(t) | s_y | \Psi(t) \rangle$.