Physics 512 **Winter 2003**

Homework Set #1 – Due Friday, January 17

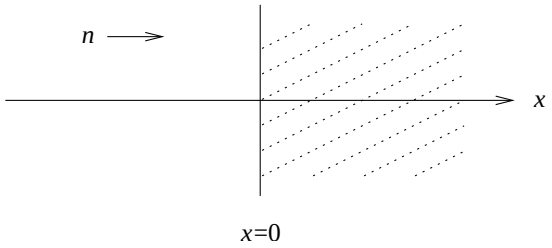
1. The Pauli Hamiltonian (for $g_s = 2$) was presented as

$$H = \frac{1}{2m}(\vec{p} - \frac{q}{c}\vec{A})^2 - \frac{q}{mc}\vec{S}\cdot\vec{B} + q\phi$$

Using the properties of the Pauli matrices (and being careful with operators), show that this may be rewritten in the equivalent form

$$H = \frac{1}{2m}\left[\vec{\sigma}\cdot(\vec{p} - \frac{q}{c}\vec{A})\right]^2 + q\phi$$

2. We model the reflection of a neutron beam perpendicularly incident on a block of a ferromagnetic material



with the Hamiltonian

$$H = \frac{p^2}{2m} + V(x), \qquad V(x) = \begin{cases} 0, & x < 0; \\ V_0 + \omega_0 S_z, & x > 0 \end{cases}$$

where V_0 and ω_0 are constant, and satisfy $0 < \frac{1}{2}\hbar\omega_0 < V_0$.

a) Assume the incident neutron beam is unpolarized. Calculate the degree of polarization of the reflected beam. Note that you may have to consider different incident beam energies.

b) Now consider an incident beam with spins aligned in the $+x$ direction. What is the direction of the spin of the reflected particles (assume $E > V_0 + \frac{1}{2}\hbar\omega_0$)?

3. Consider a system of two spin 1/2 particles with total angular momentum given by $\vec{S} = \vec{S}_1 + \vec{S}_2$ and Hamiltonian

$$H = \omega_1 S_{1z} + \omega_2 S_{2z}$$

a) Initially (at $t = 0$), the system is in a singlet state of total angular momentum. At time t, we measure $\vec{S}^2$. What results can be found, and with what probabilities?

b) What if the system is initially in the triplet state?

4. Chapter 17, Problem 4.