Q.M. H.W. #3

Griffiths : # 7.1, 7.2, 7.3, 7.5

Ohanian :

6. A particle of mass m is confined to a one-dimensional infinite square potential well that extends from $x = 0$ to $x = L$. The energy eigenvalues for the (nonrelativistic) Hamiltonian are (see Section 3.2)

$$E_n = \frac{n^2\pi^2\hbar^2}{2mL^2}$$

If the mass of the particle is small or if the length L is small, the energy eigenvalues will be large, and the particle may become relativistic (this happens if the energy is comparable with or larger than mc^2). The relativistic Hamiltonian is

$$H = \sqrt{p^2c^2 + m^2c^4} - mc^2$$

(a) Use first-order perturbation theory to find the new energy eigenvalues that correspond to this relativistic Hamiltonian.

(b) The energy eigenvalues obtained by first-order perturbation theory are actually the *exact* eigenvalues for the relativistic Hamiltonian. Explain carefully why this is so.

12. Suppose that the electron in a hydrogen atom is perturbed by a repulsive potential concentrated at the origin. Assume that the potential has the form of a delta function, so the perturbed Hamiltonian is

$$H = \frac{\mathbf{p}^2}{2m} - \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r} + A\,\delta(\mathbf{r})$$

where A is a constant.

(a) To first order in A, find the change in the energy of the state with quantum numbers $n \geq 1$, $l = 0$. [Hint: $\psi_{n00}(0) = 2/\sqrt{4\pi}\,(na_0)^{3/2}$.]

(b) Find the change in the wavefunction.

Nice sources on Pert. Theory (in this order) $\longrightarrow$

1. Griffiths
2. Liboff
3. Saxon
4. Ohanian
5. Baym