Physics 622

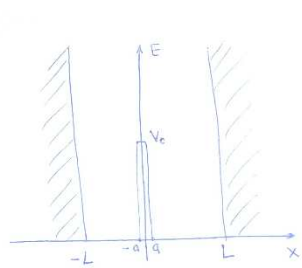
Problem set 5 *(due March 4)*

Sakurai and Napolitano problems (each problem is 10 points):

5.23, 5.32

A1 In a parallel universe there is no such thing as a spin of a particle, so the electron magnetic moment is proportional only to its orbital momentum. In that universe a hydrogen atom in state *n*=2 is placed simultaneously in parallel electric and magnetic fields, $\vec{E} = E_0\vec{e}_z$ and $\vec{B} = B_0\vec{e}_z$. Treating electron interaction with both fields as comparable small perturbations, calculate the resulting energy spectrum and new wavefunctions. The original *n*=2 state is four-fold degenerate. Does the interaction with the fields lift the degeneracy lifted by? At what values of E_0 and B_0 some degeneracy remains?

A2 A particle with mass *m* is in the ground state of the infinite one-dimensional potential well of width 2*L* with walls positioned at *x*=±*L*. At time t=0 a perturbation is turned on:



$$V(x,t) = \begin{cases} V_0 e^{-t/\tau}; & x \in [-a, a] \\ 0 & otherwise \end{cases}$$

where $a \ll L$.

Calculate (up to the first non-vanishing term) the probabilities of finding the particle in various excited states *n*>1 after a very short time $t \ll \tau$ and after a very long time $t \gg \tau$. Discuss the results.

A3 A neutron (spin ½, magnetic moment μ_n) moves along *y*-axis in the constant and uniform magnetic field $B_0\vec{e}_z$. Its spin is oriented in positive *z*-direction. At *t*=0 the neutron enters the region when an additional uniform magnetic field $B_1\vec{e}_x$. What is the probability of the spin flip (i.e. finding the spin in the negative z direction) after the particle leaves the region of non-zero B_1 at $t=t_0$?