11/18/16

QUANTUM MECHANICS (471)
PROBLEM SET 10 (hand in December 2)

30) (30 points) A system with three states has a Hamiltonian that can be represented in that basis by

$$\begin{pmatrix} E_1 & 0 & a \\ 0 & E_1 & b \\ a^* & b^* & E_2 \end{pmatrix},$$

with $E_2 > E_1$. Consider the constants a and b to be of the same size but small compared to $E_2 - E_1$.

a) Use second-order nondegenerate perturbation theory to calculate the perturbed eigenvalues. Is this procedure correct? Comment.

b) Solve the problem exactly.

c) Now use second-order degenerate perturbation theory and compare the three results obtained.

31) (10 points) Let $\mathcal{T}(d\boldsymbol{r})$ denote the infinitesimal translation operator with displacement vector $d\boldsymbol{r}$; $\mathcal{D}(\hat{\boldsymbol{n}}; \delta\phi)$ the infinitesimal rotation operator about the axis characterized by $\hat{\boldsymbol{n}}$ and by an angle $\delta\phi$; and Π the parity operator. Which, if any, of the following pairs commute and why?

a) $\mathcal{T}(d\boldsymbol{r})$ and $\mathcal{T}(d\boldsymbol{r}')$ ($d\boldsymbol{r}$ and $d\boldsymbol{r}'$ are in different directions).

b) $\mathcal{D}(\hat{\boldsymbol{n}}; \delta\phi)$ and $\mathcal{D}(\hat{\boldsymbol{n}}'; \delta\phi')$ ($\hat{\boldsymbol{n}}$ and $\hat{\boldsymbol{n}}'$ are in different directions).

c) $\mathcal{T}(d\boldsymbol{r})$ and Π.

d) $\mathcal{D}(\hat{\boldsymbol{n}}; \delta\phi)$ and Π.