PH3214 : Problem sheet

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(NOTE : *This is a sample selection of problems. You must try out more problems from other text books as well. Books by R. Shankar, Walter Greiner and Griffiths are a good source of problems.*)

1. A coherent state is given by

$$|\alpha\rangle = C \sum_{n=0}^{\infty} \frac{\alpha^n}{\sqrt{n!}} |n\rangle,$$

Find the normalisation constant C.

2. If α and β are two coherent states, find $|\langle\alpha|\beta\rangle|^2$.

3. Evaluate the uncertainty product in the n-th state of harmonic oscillator.

4. Show that for coherent state α, the minimum uncertainty product is $\hbar/4$.

5. Do problem 5.18(a) (in page 229 or 241) in Griffith's book.

6. For a particle in a periodic potential $V(x + a) = V(x)$ with N sites, and when periodic boundary conditions are applied, show that $K = 2\pi n/Na$, where $n \in 0, \pm 1, \pm 2, \ldots$. In this, K is often called quasimomentum.

7. What is meant by allowed and forbidden bands.

8. For an electron propogating in a periodic potential, whose wave function is

$$\phi(x) = e^{ikx} u(x),$$

Show that the mean momentum is $\langle p\rangle = \hbar k + \langle u|\widehat{p}|u\rangle$.

9. For an electron in an external magnetic field, the Hamiltonian is

$$H = -\gamma \mathbf{S}.\mathbf{B},$$

show that $\langle S\rangle$ will precess around $\mathbf{B}$ at a frequency $-\gamma\mathbf{B}$.

10. For an electron in an external magnetic field, the Hamiltonian is

$$H = -\gamma \mathbf{S}.\mathbf{B},$$

If the external magnetic field is aligned in the z direction, then find the eigenfunctions and eigenvalues of this system.

11. Consider two spins. Solve the eigenvalue problem for the operators S^2 and S_z. In this, S represents the sum of two spins, and S_z represents sum of the projection of spins along z-axis.