KING SAUD UNIVERSITY. DEPARTMENT OF PHYSICS AND ASTRONOMY

QUANTUM MECHANICS (453 PHYS)

PROBLEM SET 3

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August 4, 2017

PROBLEM (1)

Show that the wavefunction $u(x) = e^{-x^2/4}$ is an eigenfunction for the differential operator $(\frac{d^2}{dx^2} - \frac{1}{4}x^2)$. Then find its eigenvalue.

PROBLEM (2)

Compute the following commutators for the SHO $[N, a]$,$[N, a^\dagger]$, $[x, a]$, $[N, a^2]$.
Where N is number operator given by $N = a^\dagger a$ and $N\phi_n = n\phi_n$.

PROBLEM (3)

Calculate $\langle N \rangle$ and ΔN. Then show that

$$\lim_{n\to\infty} \frac{\Delta N}{\langle N \rangle} = 0$$

PROBLEM (4)

Given the operator $\hat{L}_+ = \hat{L}_x + i\hat{L}_y$

1. Is it hermitian ?
2. Express it in the matrix representation, and find its eigenvalues.
3. Express it in the x representation.

4. let $\Psi = \hat{L}_+ \Phi_{\ell,m}$, find Ψ in terms of the eigenstates $\Phi_{\ell,m}$.

PROBLEM (5)

Show that the spherical harmonics Y_1^0 and Y_1^1 are orthogonal.

PROBLEM (6)

An electron having $\ell = 2$, write and draw all the L_z eigenstates m_ℓ for this electron, indicating the angles.