

Physics 4610 Quantum mechanics
Quiz 4

NAME: Key

An electron is in a one dimensional harmonic oscillator potential. (For this question, you can use your textbook). Calculate the expectation value of the x between states ψ_n and ψ_{n+1} . That is:

$$\langle x \rangle = \int_{-\infty}^{+\infty} \psi_{n+1} x \psi_n dx$$

$$x = \sqrt{\frac{\hbar}{2m\omega}} (a_+ + a_-)$$

$$\langle x \rangle = \sqrt{\frac{\hbar}{2m\omega}} \int \psi_{n+1} (a_+ + a_-) \psi_n dx$$

$$\text{but } a_- \psi_n = \sqrt{n} \psi_{n-1}$$

↓

This is orthogonal to ψ_{n+1}

$$\text{while } a_+ \psi_n = \sqrt{n+1} \psi_{n+1}$$

$$\Rightarrow \langle x \rangle = \sqrt{\frac{\hbar}{2m\omega}} \cdot \sqrt{n+1} \int \psi_{n+1} \cdot \psi_{n+1} dx$$

$$\langle x \rangle = \sqrt{\frac{\hbar}{2m\omega}} \sqrt{n+1}$$