Physics 4610 Quantum mechanics
Quiz 4

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 $\psi_n$ and $\psi_{n+1}$. That is:

\[ \langle x \rangle = \int_{-\infty}^{+\infty} x \psi_n \psi dx \]

\[ x = \frac{\hbar}{\sqrt{2m}} \left( \frac{a_+ + a_-}{2} \right) \]

\[ \langle x \rangle = \int_{-\infty}^{+\infty} \psi_{n+1} (a_+ a_-) \psi_n dx \]

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

This is orthogonal to $\psi_{n+1}$

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

\[ \Rightarrow \langle x \rangle = \int_{-\infty}^{+\infty} \frac{\hbar}{\sqrt{2m}} \int_{n+1} \psi_{n+1} \psi_{n+1} dx \]

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