

The average position of a particle in quantum mechanics is called the expectation value $\langle x \rangle$.

$$\langle x \rangle = \int_{-\infty}^{+\infty} x |\psi|^2 dx$$

For any function $f(x)$

$$\langle f \rangle = \int_{-\infty}^{+\infty} f(x) |\psi|^2 dx$$

If $f(x) = x^2$

$$\langle x^2 \rangle = \int_{-\infty}^{+\infty} x^2 |\psi|^2 dx$$

The quantum uncertainty in particle position is

$$\Delta x = \sqrt{\langle x^2 \rangle - \langle x \rangle^2}$$

In quantum mechanics there are two types of variables

- sharp such as energy
- fuzzy such as position

Sharp variables the quantum uncertainty = 0