Quantum Mechanics

Covered Topics

- Application of Uncertainty Principle
- Realization of Uncertainty Principle in Daily Life
- Energy-time uncertainty relation
- References

Why isn't the uncertainty principle apparent to us in our ordinary experience…?

Planck's constant, again!!

$$\Delta x \Delta p_x \geq \frac{h}{2\pi}$$

$$h = 6.6\text{x}10^{-34}\ \text{J.s}$$

Planck's constant is so small that the uncertainties implied by the principle are also too small to be observed. They are only significant in the domain of microscopic systems

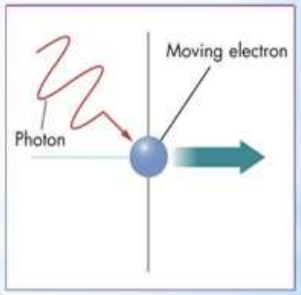
Realization of Uncertainty Principle in Daily Life

*Why this happens

*In the world of very small particles, one cannot measure any property of a particle without interacting with it in some way and this interaction changes related property.

Measuring p and x of electron

*So to determine the position accurately it is necessary to use light with a short wavelength

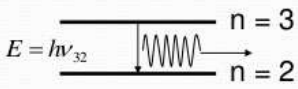


Realization of Uncertainty Principle in Daily Life

Appendix: Energy-time uncertainty relation

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

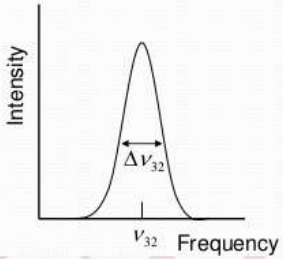
Transitions between energy levels of atoms are not perfectly sharp in frequency.



An electron in n = 3 will spontaneously decay to a lower level after a lifetime of order ~ 10^{-8} s

Energy & time

There is a corresponding 'spread' in the emitted frequency



Energy-time uncertainty relation

Example of Baseball

- A pitcher throws a 0.1-kg baseball at 40 m/s
- So momentum is 0.1 x 40 = 4 kg m/s
- Suppose the momentum is measured to an accuracy of 1 percent , i.e.,

$$\Delta p = 0.01p = 4 \times 10^{-2} \text{ kg m/s}$$

Continued.....

- The uncertainty in position is then

$$\Delta x \geq \frac{h}{4\pi\Delta p} = 1.3 \times 10^{-33} \text{ m}$$

- No wonder one does not observe the effects of the uncertainty principle in everyday life!

EXAMPLE OF ELECTRON

- Same situation, but baseball replaced by an electron which has mass 9.11×10^{-31} kg
- So momentum $= 3.6 \times 10^{-29}$ kg m/s
  and its uncertainty $= 3.6 \times 10^{-31}$ kg m/s
- The uncertainty in position is then

$$\Delta x \geq \frac{h}{4\pi\Delta p} = 1.4 \times 10^{-4} \text{ m}$$

-:IMPLICATIONS:-

- It is impossible to know *both* the position and momentum exactly, i.e., $\Delta x = 0$ and $\Delta p = 0$.
- These uncertainties are inherent in the physical world and have nothing to do with the skill of the observer.
- Because h is so small, these uncertainties are not observable in normal everyday situations.

References:

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