

# THE UNCERTAINTY PRINCIPLE



$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

THE UNCERTAINTY PRINCIPLE

# PRESENTED BY:-

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- Before starting I would like to take this opportunity to express my sincere thanks to respected “ SIR ” for giving me this project...
- Apart from that I also want to thank my FRIENDS for helping me throughout the project with his inputs..

# -: INTRODUCTION:-

- Uncertainty principle was stated by Werner Karl Heisenberg in 1927.
- This principle gives a very vital relation momentum and position of an object.
- This principle states that the position and momentum of a particle cannot be simultaneously measured with arbitrarily high precision. There is a minimum for the product of the uncertainties of these two measurements.

Continued.....

- Hence the formula for the **uncertainty principle** is as follows:-

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

THE UNCERTAINTY PRINCIPLE

# Werner Karl Heisenberg

(1901-1976)



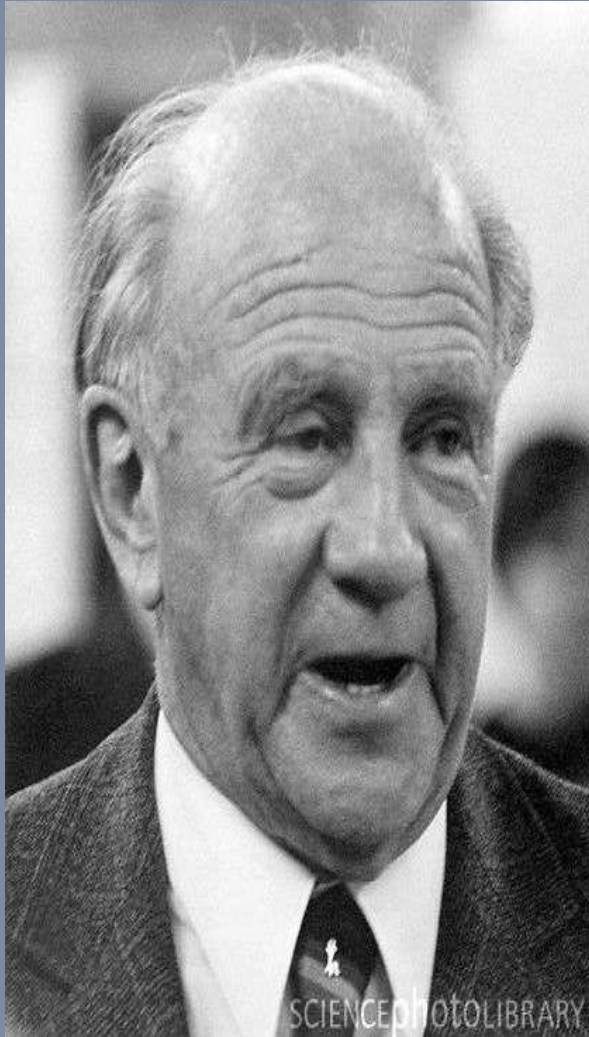
□ The German physicist Werner Heisenberg (1901-1976) received the Nobel Prize in physics in 1932 for his work in nuclear physics and quantum theory.

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□ The paper on the uncertainty relation is his most important contribution to physics.

□ In 1927, Heisenberg stated his uncertainty principle that a particle's momentum and position cannot both be determined.

Continued.....



- ❑ This means that subatomic events have to be predicted using probabilities.
- ❑ He was a very talented and intelligent student. Heisenberg impressed his teachers with his ambition and brilliance.
- ❑ He never produced other grades than straight A's, except on one occasion: During his doctorate, professor Wien of the university of Munich gave him an F in experimental physics, because he handled the laboratory equipment clumsily.

# HEISENBERG REALISED THAT ...

- In the world of very small particles, one cannot measure any property of a particle without interacting with it in some way
- This introduces an unavoidable uncertainty into the result
- One can never measure all the properties exactly

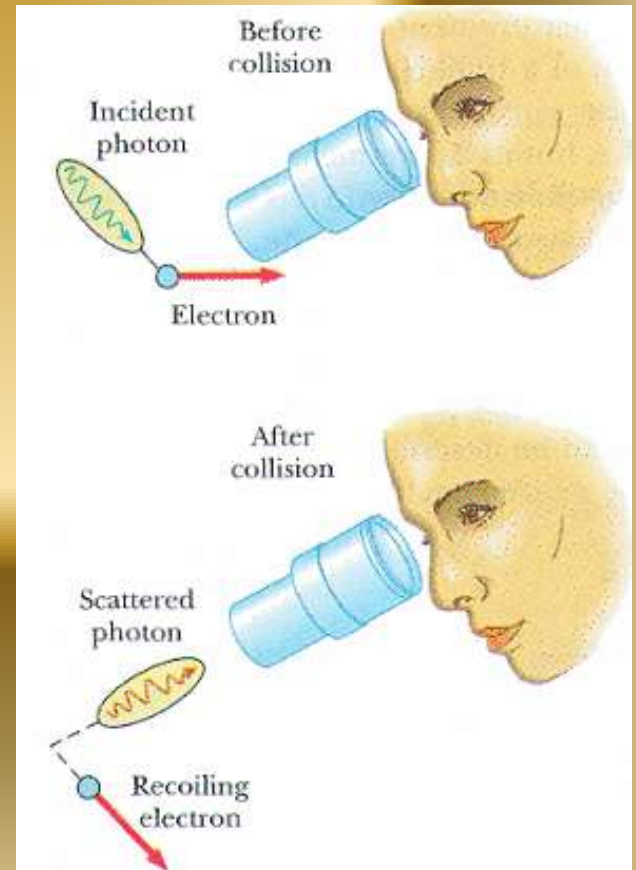


Werner Heisenberg (1901-1976)



## MEASURING THE POSITION AND MOMENTUM OF AN ELECTRON

- Shine light on electron and detect reflected light using a microscope
- Minimum uncertainty in position is given by the wavelength of the light
- So to determine the position accurately, it is necessary to use light with a short wavelength



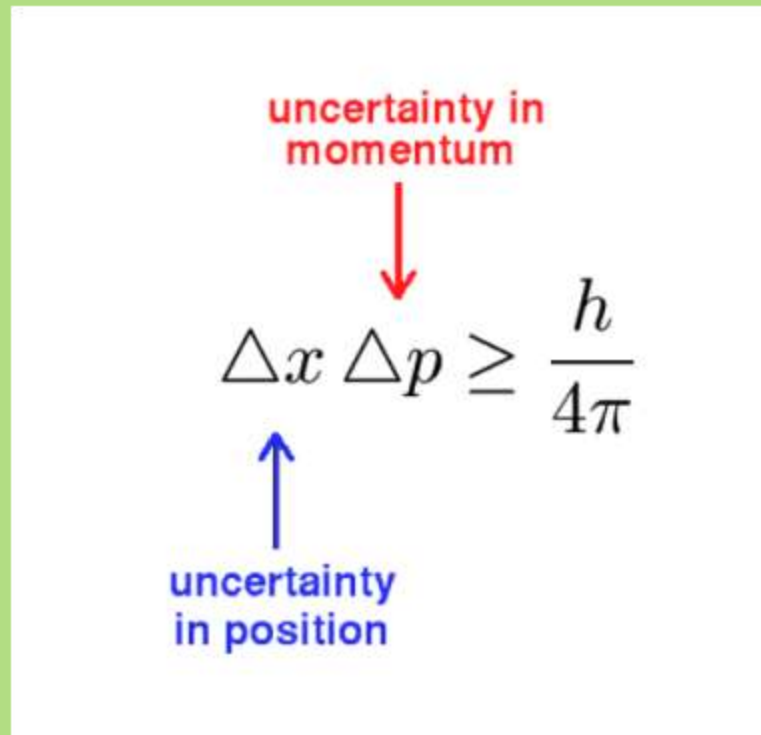
## Continued.....

- By Planck's law  $E = hc/\lambda$ , a photon with a short wavelength has a large energy
- Thus, it would impart a large 'kick' to the electron
- But to determine its momentum accurately, electron must only be given a small kick
- This means using light of long wavelength!

# Fundamental Trade Off ...

- Use light with short wavelength:
  - accurate measurement of position but not momentum.
- Use light with long wavelength:
  - accurate measurement of momentum but not position.

# Heisenberg's Uncertainty Principle



The diagram shows the Heisenberg Uncertainty Principle equation:  $\Delta x \Delta p \geq \frac{h}{4\pi}$ . A red arrow points from the text "uncertainty in momentum" to the  $\Delta p$  term. A blue arrow points from the text "uncertainty in position" to the  $\Delta x$  term.

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

The more accurately you know the position (i.e., the smaller  $\Delta x$  is), the less accurately you know the momentum (i.e., the larger  $\Delta p$  is); and vice versa.

## -: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.

# Example of Baseball

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

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

# 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  $9.11 \times 10^{-31}$  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

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



# HEISENBERG'S UNCERTAINTY PRINCIPLE

## INVOLVING ENERGY AND TIME

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

- The more accurately we know the energy of a body, the less accurately we know how long it possessed that energy
- The energy can be known with perfect precision ( $\Delta E = 0$ ), only if the measurement is made over an infinite period of time ( $\Delta t = \infty$ )

# BIBLIOGRAPHY

- [www.google.com](http://www.google.com)
- [www.wikipedia.com](http://www.wikipedia.com)

THANK

YOU