B.Tech I-SEM

HEINSENBERG UNCERTAINTY

Class Objectives

1. Introduce the concept of uncertainty.

2. Describe an experiment which highlights the uncertainty principle.

3. Explain the reason(s) for the uncertainty.

4. State the principle and give an example of the uncertainty principle.

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- It was first developed using noncommuting algebra and then by matrices.

- However this formulism was difficult to apply to problems.

Quantum Mechanics Concepts

The Uncertainty Principle

The Uncertainty Principle

- The contradictions between experimental and theory indicated, that described the phenomena for very small masses at small distances.

The Uncertainty Principle

- We start with the observation of an experiment showing *electron diffraction* (Davisson and Germer 1925).
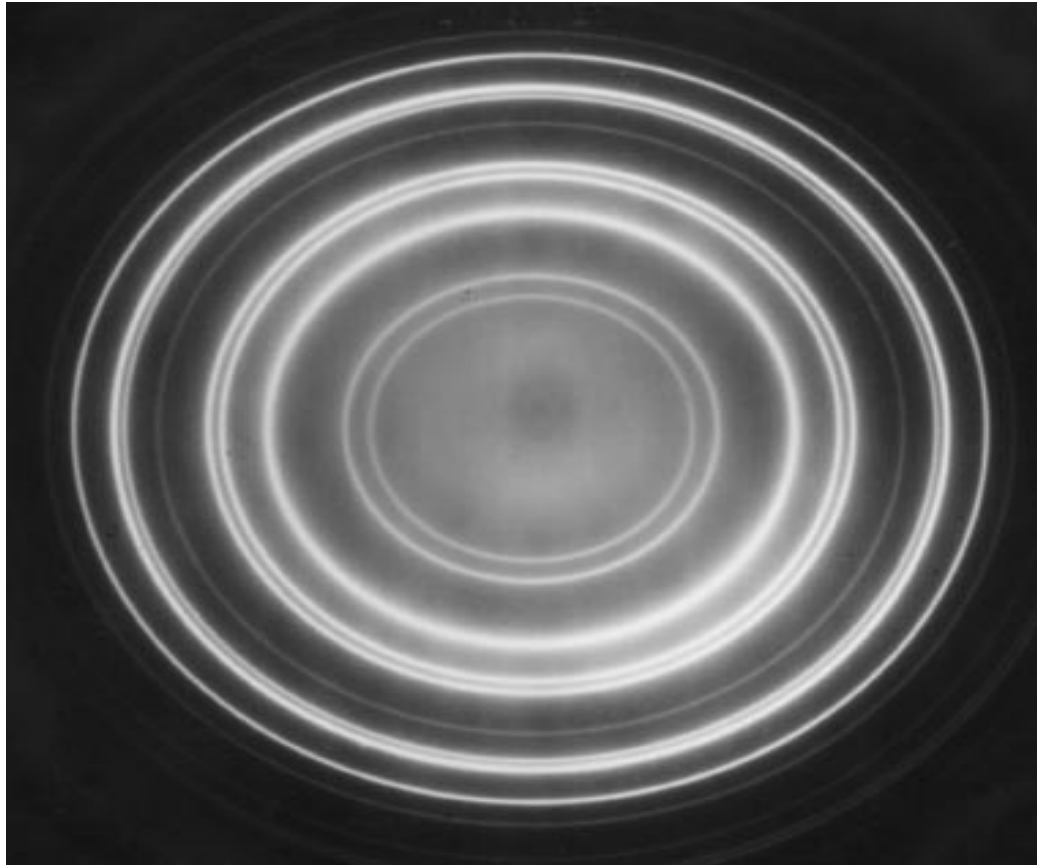
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- That is a series of maxima and minima.

The Uncertainty Principle
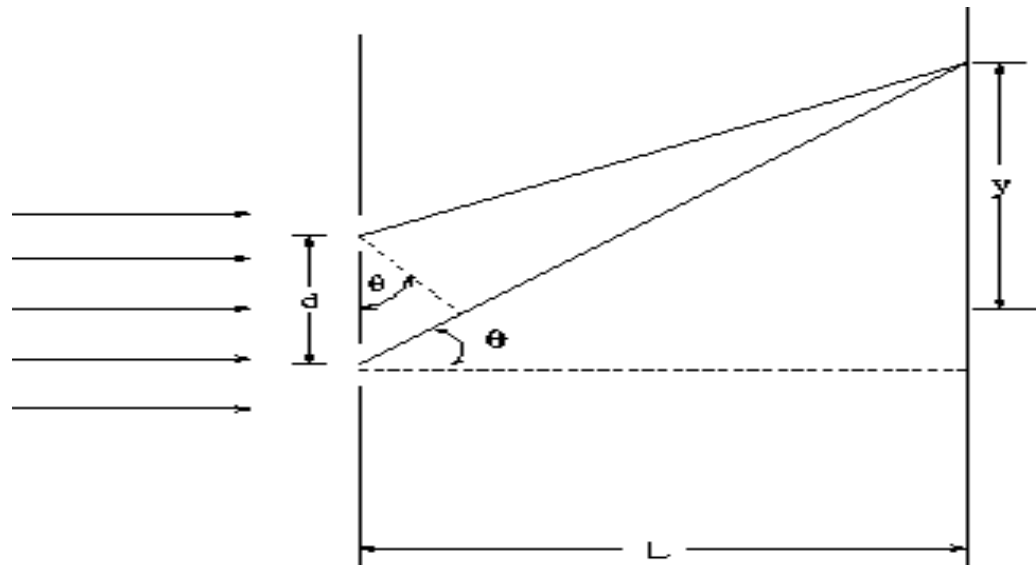
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- Classically, if both slits are open a pattern formed by a superposition should be the result.

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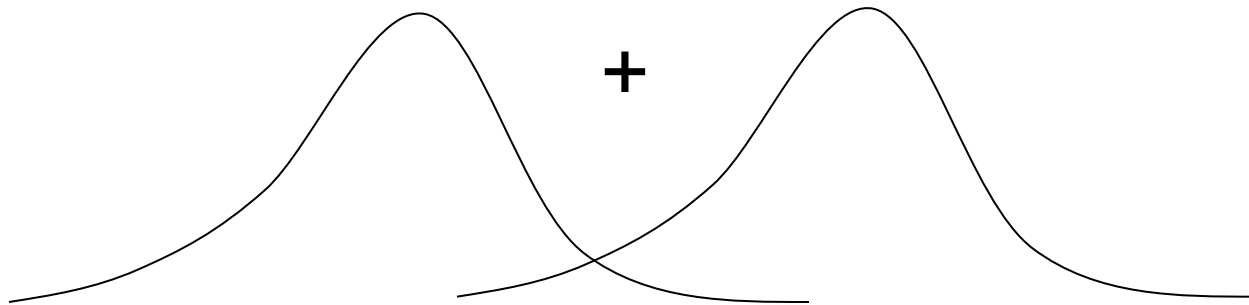
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- This forms the content of what is called the uncertainty principle.

The Uncertainty Principle

- The fact that an electron has no definite path means it also has no characteristics (quantities defining the motion).

The Uncertainty Principle

- Only when the electron interacts with a classical object can its characteristics be defined.

The Uncertainty Principle

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- The classical object is called the apparatus.

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- Reducing the accuracy reduces the effect on the particle.

- It is impossible in principle to make the effect arbitrarily small.

Heisenberg Uncertainty Principle

Effect of taking a measurement

Heisenberg Uncertainty Principle

- The uncertainty principle may be stated as:

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  If a measurement of position of made with precision Δx and a simultaneously measurement of momentum is made with precision Δp, then the product of the uncertainties can not be smaller than the order of $\hbar$.

Heisenberg Uncertainty Principle

$$\Delta x \Delta p \geq \hbar$$ (The uncertainty principle)

Heisenberg Uncertainty Principle

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- The speed of an electron is measured to have a value of $5 \times 10^3 \, m/s$ to an accuracy of 0.003%. Find the uncertainty in determining the position of this electron.

Heisenberg Uncertainty Principle

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$$= 0.77 \times 10^{-3} m$$

Heisenberg Uncertainty Principle

- From the uncertainty principle it can be shown that $\Delta E \Delta t \geq \hbar$.