WAVE VELOCITY

LALY A.S.
ASST. PROFESSOR
DEPT. OF PHYSICS
LITTLE FLOWER COLLEGE
GURUVAYOOR

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- Light waves → *Electric and Magnetic fields*
- Water waves → *Height of water surface*

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What is the quantity that varies in the propagation of matter waves?

Wavefunction(Ψ)

- The value of Ψ associated with a moving body at any point (x,y,z) in space at any instant t is related to the possibility or chance of finding that body at that position at that particular instant.
- Probability can lie between 0 and 1.
- Probability 0 means the object is definitely not at that position at that time.
- Probability 1 means the object is definitely at that position at that time.
- Probability 0.5 means there is 50%possibility for finding that object at that position at that time.
- But can never be negative. Negative probability is meaningless .

- Ψ is the varying quantity in the case of matter wave, So it can be positive and negative.
- Since a negative probability is meaningless, Ψ has no direct physical significance.
- But $|\Psi|^2$,the square of the absolute value of wavefunction known as probability density has a physical significance.
- Thus the probability of experimental determination of a body described by the wave function at any position (x,y,z)at any time t is proportional to the value of $|\Psi|^2$at that instant.

- Greater the value of $|\Psi|^2$,stronger the possibility of the presence of the object at that position at that instant.
- If $|\Psi|^2$ is very small then the possibility of the presence of the body is least at that position at that time.
- Although the wavefunction Ψ that describes a wave of a body that spreads out in space ,it does not mean that the body itself is spreading out in space.
- For example, if probability density is 0.3 ,it means that there is 30%chance of finding a body at that place at that time.and it does not mean that 30%of the body is seen at that time at that position.

Group velocity &Phase velocity

Phase velocity/wavevelocity

Wavelength of De Broglie wave associated with a body of mass m moving with a velocity v is given by $\lambda=h/mv$

Let the velocity of De Broglie wave called phase velocity or wave velocity be v_p .

Then $v_p=v\lambda$ where ν is the frequency of the wave.

According to quantum theory ,$E=h\nu$ and also $E=mc^2$.

Therefore $h\nu =mc^2$ or $\nu= mc^2/h$

Then $v_p = v\lambda= (mc^2/h)(h/mv)=c^2/v$

Since $v<c$, the velocity of De Broglie wave is $v_p>c$ ie De Broglie wave always travel faster than light. But this is an unexpected result.

To understand this result we must understand the concept of wavepacket or wave group.

Group velocity

- A wave group is similar to a superposition of a large number of waves of slightly different frequencies.The velocity of the wavegroup is called Group velocity.
- We consider a wavegroup or a wave packet to represent the wave of a moving body .
- The possibility of finding the body at any position depends on the amplitudes of the waves at that position.